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Bulletin of the

Society for the Promotion of Engineering Education

VOL. IX LANCASTER, PA., APRIL, 1919 NO. 8

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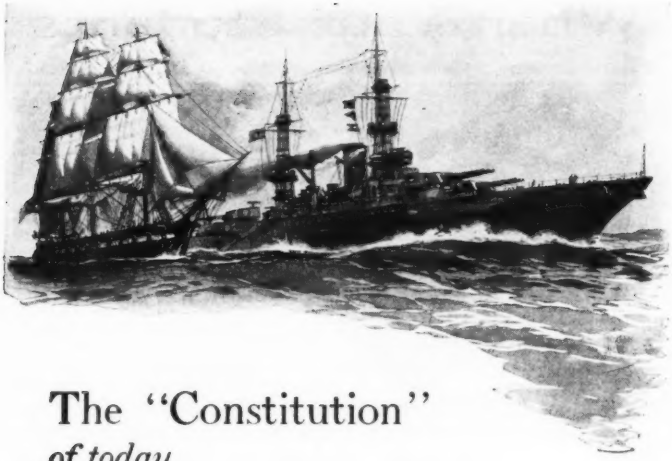

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BULLETIN

OF THE

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ELECTRICAL ENGINEERING AS TAUGHT IN AMERICAN COLLEGES.*

BY ALEXANDER GRAY, M.Sc., WHIT.SCH.

Much has been written on the subject of "Engineering Education in America," but it is thought that explicit information on the training of electrical engineers would not be without interest to readers of the London *Electrician.*

The majority of American electrical engineers are university graduates; the draughtsmen, foremen and electricians are trained by the trade schools and the correspondence schools. Evening class work is in its infancy and the standard is low. The college-trained engineer, as a rule, attends the grammar school until about fourteen years of age, then goes to the high school for four years, to the university for four years, and finally has two years of practical training in the shops or with the central station and construction companies. The young engineer is, therefore, about twenty-fours years of age before his training is complete.

The standard of the grammar school and of the high school is somewhat lower than in the British Isles, so that four years are required for the university work. During the first two years the studies are of a general character, and include mathematics, physics, chemistry, English, shop work, mechanics and drawing. During the last two years the student has to specialize in some one branch of engineering, such as civil, electrical, industrial, mechanical, mining or transportation, and the studies are almost entirely of a technical character.

Entrance Requirements.—Each applicant for admission to the engineering school must show that he possesses a good general education, and he can do this either by passing the

* Reprinted from *The Electrician*, London, Vol. LXXXI., No. 30.

university entrance examination or by presenting an acceptable school certificate. The list of subjects required for entrance to the four-year course of a high-grade school such as that at Cornell University is

Mathematics	Four units, including advanced algebra and trigonometry.
English	Three units.
Foreign language	Three units in one language.
History	One unit.
Elective subjects	Four units.

The "unit" is a recognized term used in America to indicate that the student has studied the subject five hours a week for one year; two hours of laboratory parctice are considered the equivalent of one hour of class work. The required 15 entrance units can seldom be obtained by less than four years of high school work.

The success of an engineer depends largely on his ability to meet men of education and culture on equal terms, and since the work of the four-year course is almost wholly technical, it is necessary that the student before entering college should have a thorough general education. Those who have not had this thorough preparation are advised to take a five-year course, so as to spend about one year in the college of arts.

It has already been pointed out that certificates of work done in public or private schools may be accepted in lieu of passing entrance examinations if the university authorities are satisfied with the standing of the school. The records of all students who enter by certificates are closely watched, and when it is found that the graduates of a certain high school are not making satisfactory college records, the principal of that school is notified that he must raise the standard, otherwise the entrance privilege will be denied to his pupils. A high school may thus have a passing grade of 75 per cent., but the principal will not certify that the student can meet the entrance requirements of the larger universities unless he obtains a passing grade of perhaps 85 per cent. Those who can-

not obtain this high mark are accepted by universities that have somewhat lower entrance requirements.

The Courses.—There is some variety in the type of instruction offered to electrical engineering students at the different universities. In most cases, however, the work of all engineering students is practically the same for the first two years. A typical course is given below. The entrance requirements for such a course include English, foreign languages and a thorough knowledge of mathematics, including advanced algebra, plane and spherical trigonometry, plane and solid geometry. If this entrance requirement is not met, the course must be expanded into a five-year course.

FOUR-YEAR COURSE IN ELECTRICAL ENGINEERING.

Subjects.	Credit Hours.			
	1st Year.	2d Year.	3d Year.	4th Year.
Mathematics	12	..	..	..
Physics	6	8	..	..
Chemistry	6	5	..	..
Drawing	6	8	..	..
Shop work	3	3	..	..
Surveying	2	..	..	..
General engineering	4	..	..	..
English (engineering reports)	..	2	..	..
Applied mechanics	..	8	..	..
Electrical engineering	..	2	8	22
Materials	..	3	..	..
Machine design	..	..	10	..
Mechanical engineering	..	..	12	4
Hydraulics	..	..	4	..
Business law	..	..	2	..
Industrial organization	..	..	2	..
Economics	..	..	..	4
Electives	..	..	..	8

The unit of one credit hour adopted by most American colleges may mean—

(*a*) One lecture per week for one term of 16 weeks, with the necessary homework problems and class examinations.

(*b*) One recitation on assigned work. This work generally requires two hours of preparation, and the student may be called on in class to work out problems at the blackboard.

(*c*) One computing or drawing period of three hours.

(*d*) One laboratory period of three hours.

(*e*) Three hours required in preparation of laboratory reports.

Eighteen hours of university work, therefore, means 54 hours of actual work per week, and this is about as much as any student should be allowed to carry.

There has been a good deal of discussion as to the advisability of teaching shop work in the university, the claim being made that more shop work can be learned in the factory in one week than in a whole university course. This may be the case where shop work is badly taught, but is not so when the object of the instruction is to familiarize the student with modern shop operation and processes, and with the workability of materials used in engineering construction, to give him information on the principles of manufacturing, duplication of parts and in the selection and arrangement of shop equipment. In the foundry, for example, besides receiving instruction in moulding, core making, mixing of metals, etc., consideration is given to the methods and appliances for sweep work and production in large quantities. In the machine shop, instruction is given in the use of semi-automatic and automatic machines, a few standard pieces turned out in large quantities being made for local manufacurers. The administration of the shop is intended to illustrate proper methods of shop management and operation, and to give the student a general idea of time keeping, piece work, premium work and other wage systems.

The work in the shops is all done from working drawings, and the courses in drawing, design and shop work are so organized as to secure the close correlation of these subjects.

Methods of Instruction.

Theoretical instruction is given in lecture and recitation classes. The tendency of the lecture system is to make the student procrastinate and put off studying the subject until

FIRST TERM SCHEDULE.

THIRD YEAR. ELECTRICAL ENGINEERING.

Week.	Lecture and Recitation Topic.	Reference.	Computing Room Topic.	Laboratory Topic.
1	Resistance	Art. 21–30	Resistance	Study of laboratory wiring
2	Wiring and illumination	Art. 381, 390, 392, 399	Wiring of buildings	Fuses and circuit-breakers
3	Linedrop	Art. 28–31	Wiring of buildings	Measurement of resistance
4	Work and power	Art. 16–20	Wiring of buildings	Study of meters
5	Rheostats	Art. 32–38	Rheostat design	Tests of iron
6	Magnetic circuits	Art. 39–41	Magnetic circuits	Electromagnets
7	Magnetic circuits	Art. 42–44	Examination	No-load tests on motors
8	Electromagnets	Art. 46–58	Design of electromagnet	Starters and controllers
9	Direct-current generators	Art. 12–18–63–68	Generator problems	No-load tests on generators
10	Direct-current armature windings	Art. 57, 62, 69	Generator problems	Armature winding
11	Commutation	Art. 70, 74	Generator problems	Generator load tests
12	Armature reaction	Art. 75, 79	Generator problems	Generator load tests
13	Direct-current generator characteristics	Art. 80, 85	Generator problems	Motor load tests
14	Direct-current motor operation	Art. 86, 92	Motor problems	Motor load tests
15	Direct-current motor characteristics	Art. 93–104	Motor problems	Speed control
16	Efficiency and losses	Art. 105, 112	Examination	Stray power tests

The text for recitation is Gray, "Principles and Practice of Electrical Engineering," and for laboratory is Karapetoff, "Experimental Electrical Engineering."

just before examination time, when much cramming has to be done. If the course happens to be one in which three or more lectures are given each week, the student becomes swamped, and cannot get the full benefit of the lectures, because he has not mastered what has gone before. Because of this, the large classes are subdivided into groups of about fifteen men each and placed under capable instructors. The work of the recitation is assigned in a particular text, and the student is expected to put in at least two hours of preparation, and then in the recitation to present his difficulties, and have them discussed by the instructor. It might seem that this works a hardship on the able student, because he is held back to the speed of the average student; but this is not necessarily the case if the recitation groups are selected so that the able men discuss more difficult problems during the recitation hour. A two-hour course if given to a large class will generally consist of one lecture and one recitation each week. The lecturer will treat the subject broadly, and will leave the details for the recitation hour. The student does not have to take lecture notes, because he is examined on the work of the recitation, and that work follows a good text book.

American students object to the taking of lecture notes, and will generally arrange that when a text book is not closely followed the teacher shall hand over his notes to a student committee, which will have copies made and sold to the members of the class.

A large number of problems are set for home work during the first two years. The number of such problems is reduced for advanced students, and the laboratory and design classes are arranged so as to give a thorough drilling in the application of theory. In the engineering laboratories the men work in groups of three, but each student has to hand in for correction a written report, which must include the theory of the experiment, the experimental results and a discussion of these results. The men are left to their own initiative, and the laboratory instructor is supposed to maintain discipline and be

available for reference; but is not supposed to instruct the students or to help them in the carrying out of the experiment.

The complete schedule of work is made out at the beginning of the term under the supervision of the head of the department, and this schedule, the result of experience with previous classes, is adhered to rigidly, so that a teacher cannot allow himself to be side-tracked, nor is there the usual rush at the end of the session to cover the necessary ground. A typical schedule for the first term of the third-year electrical work is given below, as also are samples of the instruction sheets which are handed to the students in the computing room and in the laboratory.

THIRD YEAR—ELECTRICAL ENGINEERING.

Problem Work for 11th and 12th Weeks in Computing Room.

Subject.—No-load Characteristics of a Direct-current Generators.

The following data are given for a direct-current generator:

Poles	Four
Output	25 kw.
Volts	120
Speed	900 revs. per min.
Slots	49
Conductors per slot	Eight (0.06 × 0.32 in.)
Coils	98 (multiple winding)
Turns per coil	Two (mean turn = 50 in.)
Commutator bars	98
Brush studs	Four
Brush shift	18 electrical degrees
Pole enclosure	0.7
Shunt field winding	1,400 turns per pole of No. 14 B. & S.

1. Plot the no-load saturation curve from the following data:
   Volts: 6, 20, 40, 60, 80, 100, 110, 120, 125.
   Field current: 0, 0.14, 0.36, 0.59, 0.9, 1.4, 1.85, 2.87, 3.6.

2. If the speed is constant at 900 revs. per min., plot no-load terminal voltage against resistance of the field coil circuit for the following cases:

(*a*) Separately excited from a 110-volt line.

(*b*) Self-excited and shunt connected.

(*c*) Self-excited and compound connected.

Which machine is most sensitive to field rheostat adjustment?

3. Specify the graded field rheostat to change the voltage from 120 to 40 volts for the three connections. The resistance of the shunt field winding is 35 ohms.

4. With the field circuit rheostat short-circuited, find the terminal voltage at speeds of 225, 450, 900 and 1,250 revs. per min. if the machine is

(*a*) Separately excited from 110-volt mains.

(*b*) Shunt-excited.

Which machine is most sensitive to change of speed, and explain why it is so without mathematics and without reference to the figures found above?

Subject.—Load Characteristics of Direct-current Generators.

1. Draw the external characteristic from no load to 50 per cent. overload for the above machine when separately excited, the no-load E.M.F. to be 120.

2. Find the number of series turns required for flat compounding, and find the size of wire for the series coils, allowing 1,000 amperes per square inch. Why can the current density in the series coils be greater than the shunt coils, in which it is 888 amperes per square inch?

3. Draw the external characteristic of the above machine as a shunt generator, the no-load E.M.F. being adjusted to 120 volts.

Laboratory Work for 11th and 12th Weeks.

Subject.—Direct-current Generator Characteristics (non-Interpole Machine).

Object.—To determine how the terminal voltage of a constant-speed generator varies with load:

(*a*) The machine separately excited.

(*b*) The machine shunt excited.

(*c*) The machine compound excited.

Reference: See Karapetoff, "Experimental Electrical Engineering"; Gray, "Principles and Practice of Electrical Engineering," pages 71–77.

Note.—The terminal voltage should be adjusted to the same value on no-load for each test. Do not forget to measure the cold and hot resistances of the armature circuit.

Report.—The report should contain, in addition to the original data sheet:

(*a*) Object of experiment and list of apparatus used,
(*b*) Short outline of theory,
(*c*) Answers to specific questions given below,
(*d*) Diagrams of connections, using standard conventions,
(*e*) Observed and computed data, with sample computations,
(*f*) Curves prepared in accordance with practice,
(*g*) Discussion,
(*h*) Original data sheets.

Note that the theory must not be copied directly from the text, nor should the report be a disjointed set of answers to questions. The curves and data must be in ink, and the final grade of the report will depend on the accuracy and clearness with which it is expressed, the neatness and orderliness of the arrangement, and the way in which the work is carried out in the laboratory.

Questions:

1. Why does the terminal voltage of a separately excited generator decrease with increase of load? How much of the drop at full load is due to the armature resistance?

2. Why is the voltage drop greater in the shunt than in a separately excited generator?

3. What would be the effect of shifting the brushes further forward from the neutral portion?

4. What is the principal advantage of the compound generator?

5. How would the terminal voltage of a compound generator vary with increase of load if the series field coils were connected so as to oppose the shunt coils?

6. If the generator is over-compounded while flat compounding is desired, what can be done to fix the machine?

7. If the voltage of a shunt generator builds up when the generator rotates in a given direction, will it build up if the direction of rotation is reversed?

The work of the computing room in the fourth year consists largely of the predetermination of the characteristics of machinery and the selection and arrangement of the electrical apparatus required for power generation, transmission and distribution. An induction motor problem is given below to which not less than eight computing periods, each of three hours, would be devoted.

Course E 21. Due on May 18th. Second Term, 1917–18.

INDUCTION MOTOR DESIGN.

Data: 75 H.P., 440 volts, three-phase, 60 cycle, 720 syn. revs. per min.

Stator.

External diameter	33 in.
Internal diameter	26 in.
Frame length	6.5 in.
Centre ducts	None
End ducts	Two, each 0.5 in.
Slots per pole	12.
Size of slot	0.36 in. by 1.6 in.
Cond. per slot	10.
Winding	YY.
Size of cond.	0.11 in. by 0.22 in.
Air-gap	0.035 in.

Requirements:

1. Re-design the stator for a motor rated at 100 H.P., 440 volts, three phase, 60 cycle, 720 syn. revs. per min., using the same punchings as for the 75 H.P. machine given above.

2. Design a squirrel-cage rotor to give a starting torque of 1.5 times full-load torque, with a full applied voltage for the 100 H.P. machine.

3. Design a phase-wound rotor for the 100 H.P. machine; specify the external resistance required to give maximum starting torque, and also that for full-load torque with full-load current in the stator.

4. Fill out design sheet similar to that on page 402 of Gray's design, and make freehand sketches showing the approximate proportions and the mechanical and electrical construction of the machines.

5. Draw a circle diagram for one of the motors, and tabulate a few characteristic values from it. Check the performance data at some load with those obtained from the equivalent electric diagram.

Option:

Extra credit will be given for an investigation of the performance of the machine as induction generator.

Initiative, resourcefulness and *originality*, as well as a *clear and forceful* presentation of the *results* in the report, will be given considerable weight in the mark.

Reference: Gray's "Elect. Mach. Design," Chapters XXVII.–XXXIX.

The work of the senior laboratory is of a more advanced nature than that of the third year. At Cornell University it has been found satisfactory to give the student a large number

of suggestive questions around which he can write a report. Such a set of questions, along with the laboratory instructions, are given below for an experiment on the alternator, which experiment will require one hour of study in class before the experiment is performed, two afternoons of work in the laboratory, and a minimum of ten hours for the write up. Many of the students will prepare what is almost a treatise on the subject.

EXPERIMENT NO. 16—TESTS ON ALTERNATORS.

Object:

(*a*) To predetermine the efficiency of an alternator from the total losses, including the load losses, and draw the efficiency curves for 100 per cent., and also for 60 per cent. power factor.

(*b*) To predetermine the regulation from no-load and short-circuit tests, draw the regulation curves for 100, 80 and 20 per cent., also zero power factor, and compare the 100 per cent. power factor curve with test curve.

The following order of procedure is generally followed in practice:

1. Make no-load saturation and core loss test.
2. Find the stray power loss.
3. Make the short-circuit test, and at the same time measure load losses.
4. Draw the no-load saturation curve, also the optimistic and pessimistic curves for full-load current and zero power factor.
5. Make the full-load saturation test at approximately zero power, using a synchronous motor for load.
6. Take data for regulation curve at 100 per cent. power, factor up to 25 per cent. overload, keeping exciting current constant.

Note.—When shutting down, keep exciting current constant and note that short-circuit current is practically independent of frequency. What is the explanation?

The following curves must appear in the report:

A. No-load saturation.
Short circuit.
Synchronous reactance.
Optimistic.
Pessimistic.
Experimental, zero power factor full-load saturation.
Computed 80 per cent. power factor full-load saturation both leading and lagging.

Computed 20 per cent. power factor full-load saturation both leading and lagging.

B. Regulation by calculation at 100, 80 and 20 per cent., and zero power factor both lagging and leading. Take synchronous reactance from actual zero power factor saturation curve.

C. Losses against full-load current at 100 and 60 per cent. power factor lagging.

D. Efficiency against kilovolt-amperes at 100 and 60 per cent. power factor lagging. Give necessary theory and vector diagrams.

Course E 28. EXPERIMENT NO. 16. 1917–18.

QUESTION SHEET ON ALTERNATORS.

Reference: Karapetoff, Arts. 558–560, 572–574, 577, 578, 581–583.

A. Answers should be known before recitation hour.

1. What are the three important points in the performance of an alternator with respect to which guarantees are usually made in contracts of sale?

2. What are the losses in an alternator? How is each of these losses determined experimentally? How is efficiency obtained from losses?

3. An alternator is rated in kilovolt-amperes and the efficiency is guaranteed at 85 per cent. power factor. What do you take for the alternator output?

4. What factors affect the regulation of an alternator?

5. How are these factors affected by a change in power factor with a given kilovolt-ampere output?

6. Which of these factors has the greatest effect at unity power factor? Which at zero power factor? Explain by vectors.

7. What is meant by "optimistic" and "pessimistic" limits of regulation of an alternator?

8. What attachment would have to be made to the alternator to make it self-exciting?

9. How would the excitation vary with the current remaining constant, power factor varying?

10. Why is it not possible to test a 10,000 k.v.a. alternator by input output method?

11. If it could be done, would it be more accurate than by method of losses?

B. To be taken up in recitation.

1. Give the general theory of the optimistic method of predetermining regulation.

2. Give the general theory of the pessimistic method.

3. What is meant by synchronous reactance?

4. Are there any methods which give more nearly correct values than either of the above?

5. Why does the synchronous reactance obtained from load test at zero power factor differ from the synchronous reactance from short circuit?

6. What is meant by armature reaction? How does it affect regulation?

7. What is meant by stray load loss? How obtained?

8. What excitation loss do you use to meet guarantee in question A[3]?

9. Why has the rotating field construction superseded the rotating armature type except for small low voltage machines?

C. Answers to the following must be known.

1. Describe in detail the method of obtaining armature copper loss from the short-circuit run.

2. Is this greater or less than the I^2R loss? Why?

3. In computing copper loss from the short-circuit run, should the iron loss be taken into consideration?

4. Having obtained the regulation curve for zero power factor, how do you obtain the regulation for any other power factor?

5. How does the predetermined regulation for 100 per cent. power factor differ from the experimental regulation? Give reasons.

6. In purchasing an alternator, what points in guarantee would you be most insistent upon having fulfilled?

7. Note that regulation at 20 per cent. power factor load is little better than at zero power factor load.

8. Alternating-current generators were formerly designed with 6 and 8 per cent. inherent regulation at 100 per cent. power factor. To-day very little attention is paid to regulation, and regulations of 15 to 20 per cent. are common. What factors have led to this change?

9. Why is such poor regulation satisfactory in practice?

D. Other questions of interest:

1. Why are delta windings used so little as compared to star-connected windings?

2. Why are reactances sometimes used in leads from alternating-current generators to bus bars?

3. Why are reactances sometimes used in feeders from bus bars to load?

4. Do synchronous motors constitute a more or less favorable load for alternating-current generators than induction motors of corresponding ratings?

5. If a turbo-generator is guaranteed to meet a rise of 50 deg. by thermometer, but on test shows a rise of 45 deg. by thermometer on the coil ends, 90 deg. rise by thermo-couple at the hottest part of the coil within the core, would you accept the generator in spite of its failure to meet the guarantee by thermometer?

6. How should temperature rise be specified in contracts for large turbo-alternators?

7. When two generators are operating in parallel, what holds them together? Why is it that two generators connected in series will not stay in synchronism unless mechanically connected?

8. A plant was installed with engine, generator and boiler capacity to operate a 75 per cent. power factor load. Power factor is raised to 100 per cent. by synchronous motors, but the kilovolt-ampere output is unchanged. Will the plant operate satisfactorily?

9. Would the instantaneous short-circuit current be the same for a given field excitation as was obtained in the short-circuit run?

Penalties.—A very elaborate system of prerequisite subjects is enforced, so that, for example, a student is not permitted to enter the second year physics course until he has passed the physics and mathematics of the first year, nor is he permitted to take the electrical engineering course of the third year unless he has passed the physics, mechanics and electrical engineering of the second year. Students who have failed in one or more subjects cannot, therefore, graduate on time, and considerable care is necessary in planning their work, so that class advisers are appointed who see that the students do not get into difficulties. Each student has his study card checked up by the class adviser, and is not allowed to take more work or less work than is stated thereon. If a student finds that his work is becoming too heavy, and that he wants to drop part so as to do the remainder successfully, he has to consult with his class adviser as to what part may be dropped. No student is allowed to take less than 17 credit hours per term or more than 20 unless special permission is granted by the petition committee. The pass mark in most colleges is 60 per cent., this being the average mark obtained from the class examinations and from the mark obtained in the daily recitations and in the computing room. Three times

during each term the whole class record is sent over to the department office, and those whose work in one or two subjects would indicate that they are not progressing satisfactorily, are called before a delinquency committee and asked to state the reasons why the work is unsatisfactory and what they expect to do to get it in shape again. By this means loafing and unsystematic study is discouraged. If the student obtains a class mark in any subject between 40 and 60 he is given a conditional mark and allowed to proceed with his work; but he must pass what is called a make-up examination within one year after obtaining the condition, and if he fails in this trial he has to repeat the work over in class. Any student who obtains a mark below 40 is not allowed to proceed with that subject. At the end of the term the records of those students who have obtained conditions or failures in one or more subjects is brought up before the doubtful case committee. If a student has obtained a condition in more than one third of his work he is put on probation, and if his record is very bad, so that the committee feels that he cannot proceed and do justice to his work and to his teacher, he is asked to leave college for the remainder of the year and come back and repeat all of his unsatisfactory work. In this way he graduates one year later than the rest of the men in the class.

Regular attendance is required at all meetings of the class, the roll being taken by having a seat assigned to each student, and the names of the students who should be in the vacant seats are noted by the janitor or by an instructor. The attendance record is displayed, so that the student may verify his record. If the student is absent without excuse from more than 10 per cent. of the meetings of the class he is dropped from the course, and excuses can be obtained only when a doctor's certificate is shown. If a student has a considerable amount of sickness, and has done creditable work until taken sick, he is given a mark of "incomplete" and allowed to make up his unfinished work when he can find time.

The laboratory reports have to be handed in for correction

within one week of the date on which the experiment was performed. If this report is unsatisfactory it is handed back for correction, for which another week is allowed. A report which is more than two weeks late is given a grade of zero.

The reasons why a student may be put on probation have already been stated. No student on probation can represent the university either individually or with any student organization either at home or abroad, nor can he take part in any student activity or hold any class office, nor be a member of any athletic team or student organization. A student is removed from probation only by the completion of one whole term of satisfactory work.

These many restrictions will appear rather strange to teachers in England, but have been found necessary in order to maintain a high order of scholarship, especially when the classes are large. Before the war the engineering colleges of America were graduating about 4,000 students each year, and, in spite of the restrictions mentioned, only about 40 per cent. of the men who enter the university graduate in the four years. The greatest elimination takes place in the second year, when many students find that they cannot stand the pace, while others decide that they have entered the wrong profession. One of the problems of the American colleges is to maintain a high average of scholarship by enforcing discipline and still take care of the development of the few students of unusual ability who do not, as a rule, thrive well under ironclad rules.

Student Organization.—It is impossible to discuss the many student activities but the student organization cannot be overlooked. In America the undergraduate body is organized according to the year in which they expect to graduate; thus the class of 1920 contains all arts, science, medical and law students who expect to graduate in June of that year. Such a method of organization is better than one in which the students are grouped together according to the college to which they belong, because the engineering student meets young

arts, medical and law students at the class functions, and begins to appreciate that all lawyers are not crooks, that medical men are not infallible, and that arts students may be live men even although they are studying dead languages. Since the engineering colleges are generally the stronger numerically, and since they take their full share in athletics and in other student activities, there is no tendency on the part of even the faculty of the college of arts to consider the engineering student as an educated plumber. Many of these students do a considerable amount of work in the arts college and elective subjects, such as psychology, public speaking, English literature, history and economics, are very popular.

The type of instruction just described is typical of that given at practically all of the engineering schools; but there are signs that changes may be expected, particularly along the line of closer correlation with industry and with the purpose of eliminating unsuitable students earlier than in the second year, and also testing and grading students for initiative and judgment as well as for their ability to pass examinations. Much information on these subjects will be found in the TRANSACTIONS and PROCEEDINGS of the Society for the Promotion of Engineering Education, and it is hoped that a better understanding of the discussions of this society will have been made possible by the information contained in this article.

POLARIS OBSERVATIONS FOR AZIMUTH IN NORTHERN LATITUDES.

BY J. MAUGHS BROWN,

Professor of Civil Engineering, University of South Dakota.

Usual Methods.—The problem of finding a true or astronomical meridian is one that nearly every civil engineer and surveyor has to solve at some time or other, and in certain classes of work quite frequently.

There are two general well-known methods of obtaining a true meridian which are popular with engineers. These are sun observations and Polaris observations. When an error of from one to two minutes of azimuth is admissible, the former is preferred by many engineers. A solar observation for meridian may be made very easily during the usual time of work in the field by taking either direct observations on the sun in altitude and azimuth, and computing the true azimuth of the sun by means of the formula

$$\cos z = \pm \frac{\sin d}{\cos h \cdot \cos L} - \tan h \cdot \tan L \qquad (A)$$

or

$$\cot \tfrac{1}{2}z = \sqrt{\frac{\sin \tfrac{1}{2}(h+p-L)\cdot \sin \tfrac{1}{2}(L+p-h)}{\cos \tfrac{1}{2}(L+h+p)\cdot \cos \tfrac{1}{2}(L+h-p)}} \qquad (B)$$

or by means of a solar attachment to the transit.

There are many engineers who much prefer to secure meridian by means of observations on the north star on account of the somewhat greater simplicity of instrumental manipulation and the better accuracy obtained. The additional advantage of great simplicity of computations is only secured when the observations are made at the time of elongation of Polaris in its apparent orbit, or near that time. The method has long been recognized as one combining great sim-

plicity and great accuracy. After observing Polaris the well known formula:

$$\sin Z = \sin p / \cos L,$$

where the terms have the significance given later, serves to give the azimuth.

The great disadvantage in the elongation method is that at certain times of the year the star comes to the position of elongation at very inopportune times of the night, making it very disagreeable to sit up and wait for the proper time, frequently many weary miles from camp or home. In the fall and spring, when Polaris comes to elongation early in the evening, the elongation method is without an equal. At other times, in order to avoid a long vigil or a midnight ride, Polaris may be observed for azimuth about dusk and the azimuth computed from the formula:

$$\tan z = \frac{\sin t}{\cos L \cdot \tan D - \sin L \cdot \cos t} \qquad (C)$$

for azimuth at any hour angle. Although under favorable conditions the element of accuracy is still retained, for the average engineer who does not make such observations very frequently the element of simplicity has a slightly clouded title. This is due to the fact that in the use of the formula (C) above, both conversions of time and a longitudinal correction must be made. Also, for accuracy, the time of the observation should be known very closely. If the surveyor happens to be out on an extensive survey in thinly settled country where accurate time is not at hand, he must either secure the same by another observation or by making a comparison with the nearest accurate time piece, or else he will feel uncertain as to the accuracy of his results.

Following will be given methods which will secure results of the desired accuracy with a minimum of field work and computations that are not difficult.

Special Methods.—The field operation will be given in de-

tail first followed by the theory upon which the field work is based.

Field Procedure.—Go into the field at any time after dusk and set up the transit at the desired point with the vernier of the limb set at 0°. It should be needless to caution that the instrument must be in excellent adjustment and accurately leveled. The last operation is best accomplished by means of the telescope bubble. Select a pair of stars that you have data on that are approaching a position of both coming to the same vertical of the observer. Say you select α and γ Ursa Major. (See Fig. 1.) Follow the stars in their apparent motion with the vertical wires of the transit until they both arrive on the same vertical, at which time they will both have the same azimuth or bearing from you. Unclamp the upper motion of your transit, sight on Polaris, bring the line to the ground and set a tacked hub. Now read the angle between the stars and Polaris. Or, after reading the angle between the stars and Polaris, the azimuth may be referred to a line of the survey instead of placing the tacked hub under the pole star. From a table similar to the following, whose method of preparation is given later, take out the azimuth of the stars, interpolating for your latitude by means of the curves shown in Fig. 3. From the hour angle of the stars the hour angle of Polaris as given in the table is obtained by noting the difference in right ascension.

Using the hour angle of Polaris as the argument, enter a table of azimuths of Polaris at different hour angles such as found in the American Ephemeris and Nautical Almanac or the Manual of Surveying Instructions for U. S. Deputy Surveyors. The azimuth of Polaris added or subtracted to the azimuth of the stars first obtained should check the angle read on the instrument.

If a field check is not considered essential, the azimuth of the pair of stars should give a fair degree of accuracy, but in this event better accuracy could be secured by taking Polaris and some other circumpolar as the pair and computing

the azimuth of Polaris at the instant the two stars come to the same vertical in exactly the same manner. This does not give a field check, but is otherwise a very desirable method.

Theory.—By reference to Fig. 1, a chart of the circumpolar stars, it is apparent that as the earth revolves on its axis, the circumpolar stars will travel in apparent orbits about the point in the heavens where the axis of the earth produced intersects the assumed celestial sphere.

Mainly on account of the motion of the celestial equator with reference to the ecliptic, the location of the celestial pole and the true circular apparent motion of the stars remain in

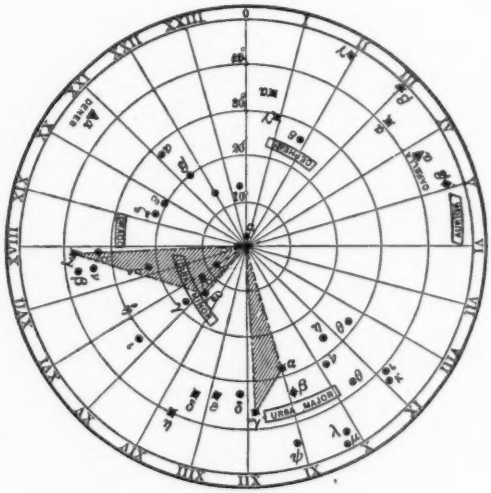

FIG. 1.

the same relative positions only for a somewhat short period of time, astronomically speaking. But this period of time in many cases is long enough to be practical in surveying computations. The changes above referred to are both small and gradual, and they will not be here discussed. The apparent

positions of the stars may be found at any time by reference to the American Ephemeris above referred to.

The following notation will be used:

Let

Z = zenith of the observer.
A = celestial north pole.
p_1 = polar distance of a circumpolar.
p_2 = polar distance of another circumpolar.
d = declination of a star.
t = general symbol for a time angle.
h = general symbol for the altitude of a star above the horizon.
ϕ = difference in the right ascension of two stars,
C = hour angle of the star whose polar distance is p_2.
L = latitude of the observer.
Co-lat. = the co-latitude of the observer = $(90° - L)$.
z = a general symbol for azimuth.

In triangle 1 (Fig. 2), the relationships existing, which may also be seen by reference to Fig. 1, will remain nearly constant for some length of time, so that the triangle formed by two

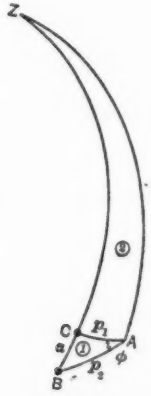

FIG. 2.

selected circumpolar stars and the pole as the vertices will appear to revolve about the celestial pole as an axis. Then from the data pertaining to these stars selected from the ephemeris, the remaining side a of this triangle may be computed by trigonometry. This value of a should remain good for the purposes here proposed for some length of time.

From trigonometry we may write

$$\cos a = \cos p_1 \cos p_2 + \sin p_1 \sin p_2 \cos \phi, \tag{1}$$

$$\sin B = \sin \phi \frac{\sin p_1}{\sin a}. \tag{2}$$

Equations (1) and (2) give us complete data on the triangle 1 of Fig. 2, the values of B found from equation (2) being independent of the latitude of the observer.

In the circular motion of triangle 1 about the celestial pole there will be found a place where the two stars under consideration will come to the same vertical, or in other words have the same azimuth from the observer. In this position the side a (CB) of triangle 1 will coincide with the side ZB of triangle ZAB, or triangle 2, therefore angle B of triangle 1 will be the angle B of triangle ZAB for any latitude.

Solving triangle ZAB for the azimuth of the stars, we may obtain from trigonometry

$$\sin z = \sin B \sin p_2 \sec L. \tag{3}$$

Calling $\sin B \sin p_2$ a constant for a given period of time

$$\sin z = K \sec L,$$

and if no check is desired this is as far as the work need be carried.

By substituting the value of $\sin B$ from equation (2) we have

$$\sin z = \frac{\sin \phi \sin p_1 \sin p_2 \sec L}{\sin a}, \tag{4}$$

or as before,

$$\sin z = K \sec L,$$

where

$$K = \frac{\sin \phi \sin p_1 \sin p_2}{\sin a}.$$

By solving equations (1) and (4), azimuth may be obtained from the position of any two stars coming to the same vertical with a small amount of labor, but in order to introduce the field check we must solve the triangle ZAB for the hour angle of the lower star. This gives the angle at A (Fig. 2).

From trigonometry

$$\cot \tfrac{1}{2}A = \frac{\sin \tfrac{1}{2}(p_2 + \text{Co-lat})}{\sin \tfrac{1}{2}(p_2 - \text{Co-lat})} \tan \tfrac{1}{2}(Z - B). \qquad (5)$$

As this value for A varies with the latitude, it should be solved in the office for two or three values including the limits of the surveying territory to be covered. In the example tables given below a much wider range has been given than is

DATA FOR TWO STAR CHECK METHOD FOR AZIMUTH.

Stars Selected, γ Draco and β Ursa Minor. β Above.

Latitude. °	Azimuth of Pair. ° ′ ″	Hour Angle of Polaris. h. m. s.
35	17 13 20	6 18 0
36	17 26 40	6 19 32
37	17 40 40	6 21 7
38	17 55 30	6 22 44
39	18 11 00	6 24 24
40	18 27 30	6 26 4
41	18 44 40	6 27 54
42	19 2 50	6 29 44
43	19 22 00	6 31 37
44	19 42 10	6 33 34
45	20 3 30	6 35 34
46	20 26 00	6 37 42
47	20 49 50	6 39 53
48	21 15 00	6 42 5
49	21 41 40	6 44 30
50	22 10 00	6 47 3

Values for azimuth taken to the nearest 10 seconds.

at all needed. Intermediate values may be interpolated by means of curves similar to the ones drawn if the tables are worked for the even degrees of latitude only. For the majority of large surveys three or four degrees at most are enough.

The data given above is for γ Draco below and β Ursa Minor above, and computed for 1918 but may be used for several years and an error of one minute in azimuth not exceeded. Hour angles given in sidereal time.

Stars Selected, a and γ Ursa Major. a Above γ.

Latitude.	Azimuth of Pair.	Hour Angle of Polaris.
°	° ′ ″	h. m. s.
35	23 54 30	1 9 49
36	24 13 40	1 12 35
37	24 33 50	1 14 55
38	24 55 00	1 17 16
39	25 17 20	1 19 40
40	25 41 00	1 21 29
41	26 5 50	1 24 41
42	26 32 00	1 27 20
43	26 59 50	1 30 03
44	27 29 00	1 32 58
45	28 00 10	1 35 50
46	28 33 00	1 38 55
47	29 07 50	1 42 06
48	29 44 40	1 45 34
49	30 24 00	1 49 00
50	31 05 50	1 52 38

If Polaris is used as one of the two stars, the solving of only two equations (1) and (4) will give the azimuth very accurately. By solving equation (5) the sidereal time of the observation may also be computed.

If the latitude of the observer is not known with a sufficient degree of precision, an additional reading of the elevation of Polaris, or of some other star, as it passes the approximate meridian determined from the data at hand will give a close value for the latitude that in turn may be used to find a cor-

rect value for the azimuth, all the field work being accomplished at one setting.

CURVES FOR INTERPOLATING HOUR ANGLES AND AZIMUTHS FOR THE ABOVE TABLE.

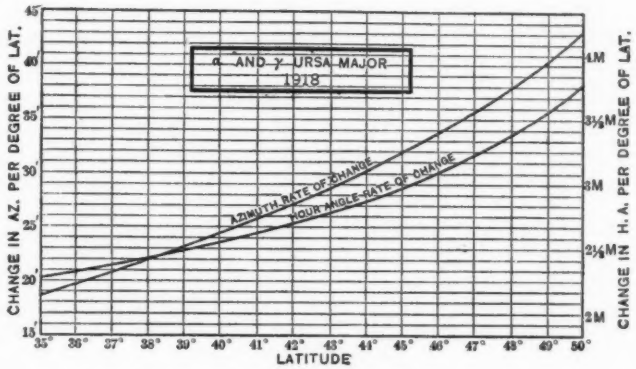

FIG. 3.

If only a few observations per season are to be made it is evident it will hardly be necessary or worth while to go to much trouble to prepare tables. The constant K for Polaris in combination with several other stars may be computed in the office for a season and used to obtain azimuth. This involves very little labor on the part of either the office or the field, and is very accurate and convenient. Following are the computations of an example.

EXAMPLE:

Date—April 24, 1918. Latitude 42° 47′ N.

The stars selected in the field as convenient were Polaris and γ Celphi.

From the Ephemeris:

	Polaris.			Celphi.		
Right Ascension	1^h	29^m	58^s	23^h	35^m	56^s
Polar Distance	1°	7′	50″	12°	49′	30″

$$\phi = 1^h\ 54^m\ 2^s = 28°\ 30.4'.$$

From equation (1). Let $\cos a = L + M$,

log cos p_1 = 9.99992	log sin p_1 = 8.29514
log cos p_2 = 9.98903	log sin p_2 = 9.34630
log L 9.98895	log cos ϕ = 9.94387
L = .97488	log M 7.58531
M = .00385	M = .00385

.97873 = cos a, a = 11° 50′ 20″

From equation (2)

	log sin ϕ = 9.67876
	log sin p_1 = 8.29514
	log sin p_2 = 9.34630
	7.32020
	log sin a = 9.31209
z = 0° 47′ 43″ about.	log K = 8.00811
	log cos L = 9.86565
	log sin z = 8.14246

The value of log K here secured may be used until the stars are no longer visible on account of arriving on the vertical position too early in the evening. In subsequent obser-

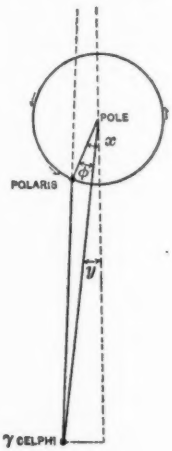

FIG. 4.

vations on these two stars it is then only necessary to multiply by log sec L to obtain azimuth.

A simple rough method of obtaining the azimuth at the above instant will be given. This may be used as a check on the above or in certain cases may suffice.

In Fig. 4 assume that the angles x and y are inversely as the polar distances of the stars Polaris and γ Celphi.

Then

$$x - y = \phi,$$

and

$$\frac{y}{x} = \frac{68}{769},$$

$$y = .088\,x,$$

$$x(1 - .088) = \phi, \text{ Difference in R.A.}$$

Solving for x gives a value of about 2 hours and 5 minutes.

Entering a table giving the azimuth of Polaris at all hour angles, or computing it by one of the approximate formulas, gives a value for z of about 47′ 20″.

The larger the difference in polar distance of the star selected from that of Polaris, the more accurate the rough method becomes. It also increases in accuracy as the stars selected come closer to the meridian.

The more precise computations first given may be somewhat differently arranged by using the tangent formula,

$$\tan B = \frac{\sin\phi \sin x \sin p_1}{\sin p_2 \sin (x - p_1)} \qquad (6)$$

where

$$x = \cot^{-1} (\cot p_2 \cos\phi),$$

to compute the angle B, and then z found from

$$\sin z = \sin B \sin p_2 \sec L. \qquad (3)$$

As equation (6) is similar to the equation (C) ordinarily used to compute the azimuth of Polaris at any hour angle, a

comparison with the usual hour angle method may be made by comparing the labor of solving the simple equation (3) to that of looking up and obtaining the relations between the different forms of time, and making a proper correction for longitude. The advantage is clearly with the method here given on the computation score alone, for one observation. When it is considered that in this method one computation may be made to serve for several observations, and that no time considerations enter whatsoever, and that there are no unreliable refraction corrections to make, and that a transit without a means of reading vertical angles may be used; the methods may be used to advantage by many engineers who now refrain from making the usual hour angle observations.

DISCUSSION OF REPORT OF COMMITTEE NO. 15 ON METHODS AND DETAILS OF TEACHING STRUCTURAL DESIGN.

The preliminary report of the committee was published in the June, 1918, BULLETIN. It consisted of three papers as follows: "The Object of the Structural Courses," by H. T. Burt; "Subject Matter," by C. T. Morris; "Training of Instructors," by J. Hammond Smith. The following discussions were based upon these and upon the chairman's presentation at the Evanston meeting by A. H. Fuller. The presentation, together with the three papers appears in the 1918 *Proceedings*.

BY CHARLES EVAN FOWLER.

The objects of the structural course should be to give the student a thorough grounding in the fundamentals of the theory of structural design, which must form the tools and weapons for his future development into a structural engineer and constructor. Like one who first learns the grammar of a foreign language, and then acquires the vocabulary by practice, the student must learn to think in moments, shears, and other basic theory, and then in practice acquire all the multitude of applications of this basic theory to real design that will in time give him that proficiency which makes the true engineer.

This presupposes that he is thoroughly equipped with the fundamentals of a common school education, and is endowed with a reasonable amount of common sense, without which he cannot hope to make a great success in any branch of engineering or applied science. The question must be answered in the first year or two of his college work in engineering as to whether he is suitable material from which to make a struc-

tural engineer, or in fact, any kind of an engineer. The writer firmly believes that the greatest mistake that is being made by engineering educators of to-day, is the attempt to make engineers of all members of an engineering class. The story is quite to the point of the young man who called upon his minister, saying that he had seen in his dreams the letters P. C., and felt this to mean that he was to Preach Christ. After a thorough questioning, he was told that he was mistaken, and that the letters in his case meant to Plow Corn! How much the world was saved in that case represents only a small percentage of the good that would result to the world if at the end of the freshman and again at the end of the sophomore year, a really thorough weeding out process could be followed, and many students directed to follow some other course of study or else some other branch of engineering than the one selected upon entering college. The truth of this is so clearly proven by the many cases of engineering graduates who eventually drift into business, manufacturing, or some other life work, and thus have wasted to some extent several of the best years of their lives. Therefore, it would seem that the purpose of the first year or two of a college course should be to determine the aptitude of the students for the life work they have chosen, and for this reason the studies prescribed for the freshman year should be such as would be good training, not only in engineering but for any life work; while for the sophomore year the studies should be largely those applying as a basis or ground work for any branch of engineering. The faculty of the engineering school should, therefore, provide a committee to sit in judgment upon the case of each student after he has completed the freshman year, and decide as to whether it is advisable for him to continue in engineering at all; and again at the end of the sophomore year to advise as to the particular branch of engineering for which each student is best suited. The teacher of structural engineering would in this way have a junior class each year, composed of students having a real and peculiar adaptability for that particular branch of engi-

neering, thus greatly simplifying the teaching problem. There would still no doubt be many slip through who would in the end become only mediocre engineers, but on the whole great good would result both to the individuals and to the engineering profession. The objects of the structural engineering course would then become more definite, inasmuch as the dead weight of a large number of drones would be removed, and much less time be wasted than by attempting to reach a fair average for the entire original class. The students would progress freely from vantage point to vantage point, and the pseudo profession of structural engineer become a real one, instead of one merely in name as at present.

The fundamentals of mathematics and mechanics as applying to structural engineering could then be developed in their application to practical examples instead of from textbooks in a purely theoretical way; the applied method certainly being best for fixing in students' minds the fundamental principles, facts and formulas, not merely of structural design, but of structural engineering. The writer has found during a practice of over thirty years that experiences in business, in legal matters, and in all things other than engineering, have at some time or other been of a peculiar benefit in solving some particular engineering problem; and lucky indeed is the student who has learned before entering college many things in business, in law, and the common things of life. More especially if they have inoculated a high degree of system and method in his work, which are among the most difficult and the most necessary to develop in the engineering student, if he has not already developed these traits.

The other things besides these two essentials of system and method which should receive more attention in engineering schools, are self-reliance and initiative. Self-reliance begins to come to the student during his college work from a thorough understanding of fundamental theory, and his ability to apply it to the practical problems of his chosen profession; and the greater degree that he attains during his college life, the more

rapidly will he acquire the full measure of it during the early years of work at real engineering, provided of course that he does not confuse cock-sureness with self-reliance.

Initiative is but a degree of inventiveness with which we as a nation lead the world; owing largely to the fact that necessity has been the mother of invention, especially with the pioneers during the formative periods of our history, and from them the later generations have inherited this faculty as a very striking feature of our national characteristics.

The structural engineer must daily, and often many times daily, work out details that are a test of his inventive ability, and which very frequently are real inventions, such as those other than engineers would often have patented. There is nothing more exasperating to the chief engineer, or one in charge of college graduates and young engineers, than to give to one of them the designing of all or part of a structure, and to have assertions made that this and that feature is impossible of solution. The somewhat exaggerated motto "Nothing is Impossible" was for many years kept on the walls of the writer's office where a large number of young designers were employed; but it had a most salutary effect, to the end that less assertions as to impossibilities were heard, and all but extremely difficult details came to be worked out as a matter of course. Nothing has pleased the writer more than to find that the scores of men working in that particular office during nearly a decade, have attained to more or less very responsible positions during the years that have followed such employment.

The scope of this discussion does not allow of a very extended exposition of the methods by which self-reliance and initiative can be developed during a college course, but I am sure that there is great merit in the suggestion that has been made to have engineering students devote some time to the study of invention. Whether this is made the subject of a separate study or not, there can be no question but what great good will result by the teacher requiring the student to find

his own way of designing reasonably complicated details; and certainly during every year of the college course, in field work, in laboratory work, and in making designs, the student should be brought to face more or less difficult situations not beyond his powers of solution, and then required to find his own method of surmounting the difficulty or solving the problem.

The foregoing paragraphs have covered very largely not only the objects of the structural course, but the "subject matter," and the "manner of presentation" as well. The subject matter already included in the courses of our engineering schools is fairly comprehensive, and perhaps there is little need to dwell upon the necessity for a greater amount of time being devoted to construction methods, both of the fabrication and erection of steel structures, and the construction of foundations; there having been a great improvement at many colleges in this respect during recent years. These practical subjects can be presented by lantern slides, moving pictures, lectures by practicing engineers, etc., but the teacher should insist upon his pupil spending as much time as possible, especially during vacation, working for a good structural plant either as a draftsman or in some capacity on actual erection even if he is obliged to serve as a laborer or timekeeper. The benefit to the student will be immediately seen in his college work that follows, as he will usually show a greater interest in his studies and a quicker grasp of the subjects.

What is true in the training of the student, is true in an increased degree in the training of the teacher. He must know the theory perfectly, but he must know as well the practical application; and this knowledge can only be gained by some years of work at practical engineering, which should be supplemented by employment on construction work. Nothing is more disgusting to the student who has spent some time on actual construction work, than to have his teacher show more or less ignorance of practical matters; and the writer knows personally of students who have nearly allowed such continued exhibitions to wreck their college careers. The teacher should

not only spend some years on practical work after his graduation, and before undertaking to teach engineering, but should spend as much time as possible during vacations, in engineering or construction employment.

The interchange of ideas between teachers through Society publications, and at conventions, has been the cause of marked improvement in the courses of study, the methods of teaching, and the results attained, but this will not suffice without a first-hand knowledge of the practical methods in use by practicing engineers and constructors. Much good often results in the introduction of new and foreign blood into the teaching staff of a college, and much that is bad often results from the immediate employment as instructor of a graduate by his alma mater; that is before he has had some years of practical experience, and before he has taught at some other school or schools; and has thus obtained that breadth of view that enables him to select from the many, those methods of teaching which give the best results and which are really best. The advice of the older teachers, those kings who as engineering authorities we reverence, is often times good, often times too conservative; so it must be mixed with the leaven of advice from the younger, more restless, and perhaps more progressive many, before there can be evolved the more perfect teacher, the most perfect method. To paraphrase Kipling,

> If you can talk with crowds, and find their virtues,
> Or walk with Kings—nor lose the *common touch*,
> Yours is Success.

BY J. A. L. WADDELL,

Consulting Engineer, Kansas City, Mo.

Through the urgent request of a member of the Committee I have been persuaded to discuss the subject of "Teaching Structural Design," although it is some thirty-three years since I left the field of pedagogy to enter that of consulting engineering practice. However, I feel that I am not altogether incompetent to treat this important matter, because I have had

so many men working under me on design in all those years that I have been able to observe their shortcomings and to speculate upon how best to overcome the defects in their education.

In the first place, I believe that the rank and file of technical men—I mean the minor draftsmen, the surveyors, the inspectors, and others of that ilk—do not receive the right kind of training. A large proportion of them have risen from the ranks, having obtained their technical instruction in the school of hard knocks; while many of the remainder have had too much education of a type they are not fitted properly to acquire. Those who have received a more or less systematic training may be grouped into the following classes:

A. Those who have studied in trade schools or night schools or who have had a correspondence-school course.

B. "Flunk-outs" from the higher-grade technical schools.

C. Unambitious graduates of the last-mentioned institutions.

In my opinion, all of the men just described would have been greatly benefited by receiving a short, limited, thorough, practical course, scientifically adjusted to their needs as wage earners, so as quickly to make them capable of rendering effective service in minor capacities, and of earning at once enough to support them comfortably in a moderate style of living. Trade schools of a greatly improved type are what such men need to fit them for their unambitious careers; and later I shall indicate of what I deem their courses should consist; but, meanwhile, I desire to say a few words about the characteristics of the men in the above-mentioned groups.

First. The peripatetic draftsmen, surveyors, and inspectors, who have had no special education other than that of the "Three R's" or perhaps that of the high school.

Sometimes these men by industry manage to make good and even to graduate into a higher class of technical assistants, but the mass of them are unsatisfactory, unreliable, and disappointing. They are simply wage earners; and their ambition

seems to be to secure as good compensation as they can for as small an amount of effective service as their employers are willing to accept. They work by the clock, and they require constant watching, not only to ensure their giving a proper *quid pro quo,* but also to prevent them from making serious mistakes in their work.

Second. Those who have studied in trade schools and night schools.

These often prove to be fairly useful assistants, but their limitations are quite restricted, and some of them at first have too exalted an opinion of the value and reliability of the education they have received.

Third. Those who have taken a correspondence course in engineering.

Most of these are very disappointing, for they think they possess knowledge which they do not. In my opinion, about the only real advantage in the correspondence school is that it makes some of its students pay attention to their technical book reading in a manner which they would not adopt when studying without help. Most individuals hate to spend money for something they do not receive, hence the correspondence-course student will generally study harder than the man who tries by his own unaided efforts to acquire technical knowledge from books.

Fourth. Flunk-outs from the higher technical schools.

Some of these manage to make good, but most of them develop only mediocre professional careers. Some of them failed to finish their course from lack of funds or because of illness and not for want of ability. Such men, though seriously handicapped, by reason of not possessing a diploma, as well as on account of insufficient scholastic training, often succeed quite well, and sometimes even reach to prominence. But those who failed from lack of ability or application, or who were expelled on account of wildness, or who were dropped because of having fallen into bad habits, seldom manage to do more than earn a bare living.

Fifth. Unambitious graduates.

Generally such men are plodders without employing much energy, perfectly reliable up to a certain point but not beyond, painstaking but not progressive, and unsafe to entrust with any work on which they are not experienced.

All such men as those above described are necessary in the conduct of engineering work; for in our profession, as well as in all other walks of life, there must always be "hewers of wood and drawers of water," and only a few can ever climb to, or even near, the top of the professional tree. Such mediocre men, however, should be made as truly proficient as their natural limitations will permit. Two or at most three years of training in a good trade school would give them a practical education which would prove invaluable; and it should be adjusted to the needs of the different callings which they desire to pursue.

The course should be one without "frills," everything taught being directly to the point and aimed to train quickly each man to earn a comfortable living. They do not need instruction in the humanities, foreign languages, economics, oratory, higher mathematics, advanced physics, chemistry, or technical mechanics; but they do require a thorough drilling in arithmetic, algebra, geometry, plane trigonometry, drafting, descriptive geometry, perspective, surveying, technical nomenclature, materials of construction, elementary physics and mechanics, and the rudiments of the English language. By the latter, I mean they should be able to spell correctly all ordinary words and the special technical ones that they are likely to use, and to prepare intelligible reports for the perusal of their immediate superiors, although not necessarily for publication. And while these subjects are being taught them, the instructors should impress upon their minds the importance and the practical application of all that they learn, so that they may be encouraged to neglect nothing in the pointedly practical and utilitarian course of instruction they are receiving.

The establishment of such trade schools would inevitably tend towards the raising of the average mentality and natural ability of the students in the higher engineering schools, and would militate materially for increased efficiency and greater accomplishment therein. This is mainly because when the course is adjusted for average minds it does not work well for either the very bright or the rather dull students, holding back the former and discouraging the latter. It is far better to grade technical students according to their capacity to receive instruction, throwing out ruthlessly the incapables and the over-slow plodders, and adjusting the higher course to the capacities of the brighter (but not the brightest) men in the classes.

If there be but four years allowed for giving such higher engineering courses, the instruction should be of a rather general nature, leaving the highest branches to be taken care of in post-graduate schools, the idea being to turn out at graduation men who are well trained in a broad way on all branches of engineering but not really expert in any, who have sound conceptions of life and citizenship, who are prepared to take quickly a prominent place in both social and business affairs, and who are capable of soon perfecting themselves in any class of professional work. This course should differ quite a little from the engineering courses given in this country to-day, mainly because its prime object would be mental culture of the highest type and the development of a capacity for right thinking and of keen conception, combined with a somewhat superficial practical knowledge of all the main branches of engineering—enough to enable the graduate to specialize speedily in any branch, and to avoid the danger of being found ignorant of practical things that he ought to know.

The post-graduate schools would provide an opportunity for any engineering graduate, desiring to continue his studies, to specialize in any line; and the course should be so thorough that the limit of current knowledge in any specialty could be reached by the students. For that reason all the courses should

be given by specialists; and the feature of true economy in design and building should pervade all instruction. There need not be many such schools, for, probably, the attendance would not be large; but they should represent the highest possible attainment in technical teaching—the *ne plus ultra* of pedagogy.

With the system of schools herein described, our country would be provided with an army of well and practically trained subordinates for all lines of technical work, an adequate number of technicists fitted to act as officers for such subordinates and capable of advancing to any height in engineering, and a small body of the most thoroughly trained engineering specialists in the world. By means of such a combination our profession inevitably would progress with leaps and bounds; and the engineering constructions of the future would surpass those of to-day to the same extent that those of the last half century have surpassed those of all the previous ages.

This scheme of dividing students into groups according to their ability and ambition has been adversely criticized as being un-American and tending to establish a caste or aristocracy; but such criticism is without valid foundation—moreover, is it possible under any practicable conditions to prevent the existence of an aristocracy of brains? Substantial national progress should not be interfered with because of any pseudo-democratic notions like the one mentioned.

But, some of you may ask, what has all the preceding to do with the questions set by Professor Fuller and his co-workers concerning the teaching of structural engineering?

Certainly it has apparently no direct bearing thereon; but without such a preamble to make clear my belief as to what constitutes the most effective method of providing technical education for our future engineers, I should not be able properly to deal with the various questions propounded; consequently, I trust that all concerned will pardon my seeming irrelevancy.

Objects.

The main objects of the structural courses should be—

First. To give the student a practical knowledge concerning the general features of engineering structures, how they are manufactured, and how they are erected under various conditions.

Second. To teach him thoroughly the general principles of proportioning those structures which are of simple or ordinary type, paying sufficient attention to practical matters to enable him to undertake at once after graduation, of course under proper guidance, the designing work for such constructions.

Third. To give him also, if time permit, an elaborate course on the theory and practice in the designing of complicated and unusual structures, so as to start him well upon the road to becoming an expert in the line of such constructions. This is properly the function of the post-graduate schools, but it might be covered regularly in other engineering institutions giving a five-year course, or as post-graduate work supplementary to a four-year course.

Subject Matter.

Professor Morris is correct in his statement that "the major portion of the work in a civil engineering course should be of a fundamental character and required of all civil engineering students." The technical school is no place in which to specialize, because the student does not know what line he is best fitted for nor what work will prove to his taste. If he has the ambition to become a specialist, let him go into a general and varied practice for a few years after graduation, so as to determine what line is best for him to pursue, then take two years of special instruction in a post-graduate school.

As it is impossible to-day to pursue a large civil engineering practice without constantly running into mechanical and electrical engineering work, it is necessary for every broad-gauge, well-rounded, civil engineer to be posted on at least the elements of mechanical and electrical engineering. The civil

engineer, however, does not often encounter mining engineering problems, hence the civil engineering student does not require special instruction in mining engineering. The converse of this, however, will not hold, because the mining engineer is constantly meeting with problems that pertain to civil engineering, hence his instruction should contain more than the mere elements in certain of the principal branches of civil engineering.

Again, mechanical and electrical engineering students need some instruction in civil engineering, but not to the extent that civil engineering students require to be taught mechanical and electrical engineering.

In the teaching of structural design, particular attention should be given to the features of economics and æsthetics in both the regular and the post-graduate courses. This statement cannot well be too forcibly made.

Every engineering student should be properly instructed in drafting, because any graduate engineer who is not a fairly good draftsman is likely at times deeply to regret his deficiency in this particular. Some young men have the idea that, if they learn to draft well, they are likely to be kept by their employers continually at drafting. While this tendency certainly exists, most assuredly the way to meet it is not through ignorance and incompetence.

The theory of reinforced-concrete design should be given in the regular course; and but little of it should be left for post-graduate instruction. The elements of steel-arch bridge designing and building should be taught in the regular course, but thorough training therein should be postponed for post-graduate instruction. This remark pertains also to movable spans, suspension bridges, and cantilevers.

In my opinion, a complete treatment of statically indeterminate stresses and secondary stresses should not be given in four-year courses, but should be left for the post-graduate school. These subjects require a great deal of time, which might better be spent on cultural and economic studies.

It does not pay to spend very much time on the study of stone-masonry structures, because reinforced-concrete structures have replaced them almost entirely; nevertheless the student should still be taught the theory of the masonry arch. Similarly, a short and elementary treatment of astronomy and geodesy might be given in the regular course, leaving a thorough study thereof for post-graduate work; because very few practicing engineers are concerned to any great extent with either astronomy or geodesy proper.

In respect to the study of languages, the members of the S. P. E. E. must be tired of hearing me preach—suffice it to say that I advocate cutting out entirely Latin, Greek, and German, making French optional and Spanish obligatory, and drilling thoroughly in English during every year of the curriculum, not failing to include practical instruction in the writing of contracts. My book on "Specifications and Contracts" was prepared specially for the use of technical students, and I believe that if it were employed as therein indicated, the graduating classes would have a fairly good knowledge of the intent in specification writing, and would be almost expert in the preparation of contracts.

Lack of space will not permit of my discussing any more of the fundamentals for engineering students enumerated by Professor Morris.

Manner of Presentation.

In respect to the manner of presentation of the subject matter of the structural courses, I shall make a few remarks concerning points in which I am specially interested, but shall not attempt to cover the whole ground or even to mention many matters of importance.

In the first place, I believe that too many subjects of a preparatory nature that *apparently* do not pertain to engineering (although assuredly necessary therefor) are crowded into the freshman and sophomore years, thus discouraging many students who desire to have substantial results constantly in sight as a reward for their efforts. Again, nearly all our technical

graduates are painfully ignorant concerning many important practical facts in engineering; and they even do not know the meaning of common technical terms or the names of the principal parts of engineering constructions. To obviate these shortcomings, I advocate giving to the freshmen, and to the sophomores (if there be not enough time in the freshman year), short preliminary courses in all subjects dealing with structures, so as to teach them the names of all the principal parts thereof (including the most important details), the characteristics of the materials that enter into the construction, the methods of manufacture, and the different ways of erection to meet various governing conditions. This would require for each course a "Glossary of Terms," and would necessitate a few trips to inspect steel-manufacturing shops and engineering works under construction. The instructor should prepare, on an ample scale, isometric drawings of the various engineering structures, writing along each principal part its name or designation. During even this preliminary course, attention should be given to the matter of economics so as to accustom the students at the outset duly to consider this most important feature of design; and, if occasion offer, the matter of æsthetics, or the lack thereof, should be brought to their attention. By mixing this practical instruction with their mathematics and other non-technical studies, the interest of the students in real engineering work would be aroused, and the entailed diversity of thought would make the course more agreeable and satisfactory.

While I believe in teaching the wheel-load method of finding stresses and moments, I should always explain that it is very seldom used in actual practice, but that the equivalent-uniform-load method is employed instead. Again, in finding stresses in steel arches, I would teach both the influence-lines method and the old-established method of unit panel-loadings.

As for the matter of giving individual problems to students for solution, I greatly favor it—notwithstanding the fact that it may take a great deal of their time—for the reason that

nothing so well impresses any theory upon a young man's mind as does applying that theory to the solution of an actual problem in design or construction. Incidentally, I might recall to the minds of some of the members of the S. P. E. E. the fact that two years ago I prepared a series of examples to illustrate the methods given in my "Bridge Engineering" for making quick computations of the approximate quantities of materials in bridges and trestles of all kinds. While a number of students in several technical schools agreed to enter the competition (for which I offered some nominal prizes), they all withdrew on account of our country having entered the European war. I am still of the opinion that the solution of that series of problems would prove of great benefit to the better class of students in structural engineering (especially those taking post-graduate work), if only for the reason that it would show them the practicability of making exceedingly-quick and fairly-accurate estimates of cost for proposed bridges of all types.

Training of Instructors.

To the list of five essential qualifications of a good teacher of structural engineering, as given by Professor J. Hammond Smith, I would add the following:

6. He must have had sufficient practical training, in all the branches which he teaches, to understand thoroughly the application of the theory to practice, and to make evident to all concerned (especially his students) that he is truly a master of his subject.

7. He must be so interested in the welfare and advancement of the engineering profession that his students will quickly become interested therein also.

8. He should be fairly well posted on the economics of all the subjects he teaches, and should dwell constantly upon this important feature of design when imparting instruction.

9. He should be so interested in ethics and equity as to in-

spire in his students correct ideas concerning these fundamental essentials for the greatest professional success.

Professor Smith's method of teaching structural engineering by combined lectures, recitations, and quizzes is the best possible way of imparting knowledge. I used it over thirty years ago; and it worked to perfection. In addition, I acted as consulting or advisory engineer to my classes; and this method of teaching proved to be eminently successful.

Much more might be said about the qualifications of instructors in structural engineering, but this discussion of mine, I fear, has already exceeded a reasonable limit. Before concluding, however, I desire to call attention to a most reprehensible practice that is altogether too common in technical schools, viz., taking men out of the graduating class and immediately making them instructors. The objections to such a custom are as follows:

First. No one should be allowed to teach any branch of engineering until he has had at the very least three years of real practical experience, not only because without practical knowledge one is absolutely unfit to instruct others in technics, but also because the students will not have a proper respect for a teacher when they know him to be merely a theorist.

Second. Inbreeding in the faculty of any institution of learning is not conducive to the highest type of development, tending, as it must, to the continuance of faulty methods and acting as a deterrent to healthy progress.

Third. It is difficult, if not altogether impracticable, for a young instructor to maintain proper order and to ensure for himself due respect when teaching students with whom for two or three years he has been on the most intimate terms.

Fourth. A recent graduate is, of necessity, rather narrow-gauge; and he cannot have the broad vision requisite for inculcating in his students either a love for the profession or the lofty ideals that are essential to true success.

DISCUSSION OF REPORT OF COMMITTEE NO. 15.

BY HALBERT P. GILLETTE,

Editor, *Engineering and Contracting.*

The writer is in full accord with Mr. Henry J. Burt's outline of the objects of structural courses. Particularly should emphasis be placed upon his statement that "it devolves on the teachers not only to prescribe the studies to be pursued during the college period, but to so train the student that he will continue in a progressive channel" after graduation.

As an editor of a civil engineering periodical, the writer has long been impressed by the fact that a large percentage of civil engineers do relatively little reading of any engineering periodicals. Whenever the writer goes to the library of an engineering society he notes what a pitifully small number of men are usually studying either periodicals or books. When he talks with practicing engineers, he finds that most of them excuse their ignorance as to recent developments in engineering, design and construction on the ground that they have been "too busy to keep up with the literature of the subject." When he sees that the total subscription lists of all the civil engineering and contracting periodicals combined do not include more than half the possible subscribers he is astounded.

The bald fact is that the majority of civil engineers cease to be real students of civil engineering shortly after they graduate. This being so (and sixteen years editorial experience on the two leading civil periodicals has shown the writer that it is so) there are but two explanations of the conditions: (1) That civil engineering periodicals do not publish usable facts, or (2) that most civil engineers have neither recognized the necessity of continuous study nor formed the habit of constantly searching for new information.

The first of these alternatives can be dismissed without argument, for nearly every recent civil engineering book is full of references to, and quotations from, articles that have appeared in civil engineering periodicals. Evidently the most studious

of civil engineers—the authors of engineering treatises—find the contents of civil engineering periodicals worth while.

The other alternative therefore seems inescapable. Of course, it may be said that the non-readers among civil engineers are those who have never gone to engineering colleges. The writer's observation gives no support to such an assumption. Indeed he has usually found that the man who has been able to train himself to be a civil engineer without the aid of an engineering college is usually more of a student of engineering books and periodicals than is the graduate of such a college. His struggle to make an engineer of himself has developed in him not only facility in searching for knowledge, but has founded in him belief in the value of such searching. *Finally, it has habituated him to be a searcher for knowledge.*

On the other hand our present courses in engineering often tend to atrophy the instinct of exploration. The teacher does the exploring, and presents to the student the results in a form readily assimilated. During four of the most formative years of life, the engineering college student is not made to search for and analyze data.

The late Professor Henry James, in his "Talks to Teachers on Psychology," says that he believes most men form nearly all their habits before they are twenty-five years old. The writer believes this to be a fact. Granted that it is, how pitifully weak becomes the argument that engineering students need not be trained in searching for data because that is a training that they will naturally impose upon themselves after graduation.

The writer fears that in the desire to teach students the "principles" of science and engineering, a great error is being made by many teachers. Principles, it is true, should be taught. But without a great store of details in one's mind, or readily accessible, principles can not be put to the best use in practice. In fact a strong argument can be advanced in favor of the proposition that principles should be taught only after many details of practice have been learned. Certainly, the

greatest thinkers have been the men who have first acquired detailed knowledge and from the details have themselves derived the principles.

Reversing this process makes matters easy for the teacher and easy for the student; but does it not lead to the student's becoming perpetual nestlings, waiting like young robins for worms to be brought to them? Instinct saves the young robins from an everlasting life of being fed, but there seems to be no searching instinct that leads the average man to hunt for knowledge. The habit of searching must be trained into him.

The teaching of "principles" has become almost a fetish in America. What is a principle that entitles it to so much reverence? A principle is merely a law that expresses a factor common to many individuals or classes of facts. A knowledge of principles therefore greatly reduces the strain upon the memory and facilitates the operation of the mind. But known scientific principles are countless in number, and they are daily increasing by the hundreds. It is beyond the power of any human mind to memorize more than a small fraction of all the scientific principles now in print. True, some principles are of wide scope and others are narrow; but if the teaching of principles is to be the prime object, well may it be asked where the line is to be drawn.

More and more it grows upon the writer that the formation of habits to be pursued in after life should be the prime object of teachers. Students can certainly not be taught many details, nor in fact can they be taught many principles, relatively speaking. But they can be taught how and where to search for information, how to classify and organize the knowledge thus acquired, and how to go about to apply the knowledge.

Mr. Burt puts it very well when he says that one of the purposes of training is "To develop in the mind the powers of analysis, synthesis, observation, imagination and logic, so that the man will always be a student." The writer is glad to see mention made of "logic." There are few engineering colleges

that require the study of logic as a formal course. Unfortunately there is no very satisfactory text book on logic. Perhaps Bain's is the best one for class purposes. Some teachers prefer Jevons. But there is no doubt that the study of formal logic is very useful as a training in the use of words as tools for reasoning. Less can be said of existing books on logic as aids in inductive reasoning. No logic whatever discusses inventive or imaginative reasoning. Hence teachers of logic must themselves go beyond the covers of the text books on logic if they are to arouse deep interest in the truly fascinating science of systematic thinking.

It may serve to bring out more specialized discussions of structural engineering if the term structural engineering be first defined. The writer was recently asked by the Illinois Structural Engineers' Association to assist in defining structural engineering. The accompanying editorial from *Engineering and Contracting*, December 25, 1918, contains the writer's contribution to this question.

Who Is a Structural Engineer?

The Illinois Structural Engineers' Association has asked the editor's assistance in framing a definition of Structural Engineer. The first step involves defining engineering.

An editorial entitled "Who Is an Engineer?" appeared in our issue of December 4, and we there gave the following answer: An engineer is one whose vocation is the systematic study of science and the application thereof to problems of economic production.

In this definition the word "production" is to be used in its broadest economic sense. It even includes the effects produced by the military engineer; for while military engineering has for its ultimate object the defeat of an enemy, the attainment of that object is best assured by the application of science in an economic manner.

What is a structure? The following definitions are given in the leading American dictionaries:

Structure: That which is built or constructed; an edifice or building of any kind; in the widest sense, any production or piece of work artificially built up, or composed of parts joined together in some definite manner.—The Century Dictionary.

Structure: A combination of related parts, as a machine, a building or a bridge.—The Standard Dictionary.

Structure: Something constructed or built, as a building, a dam, a bridge; especially a building of some size, an edifice.—Webster's Dictionary.

Structural engineering includes the design and erection of modern large structures.—Webster's Dictionary.

None of these definitions will meet the approval of structural engineers. A structural engineer does not ordinarily design machinery, yet the Standard Dictionary definition specifically includes a machine, and the other two definitions do not exclude machines from structures.

"A piece of work artificially built up or composed of parts joined together in some definite manner" is a definition that seems to include all engineering structures, but it also includes things that no engineer would characterize as a structure. A lady's hat would fall within this definition.

Before considering both what must be included and excluded from a specification of the word "structure," let us examine three definitions of Structural Engineering, each to be found under the head of Engineering:

Structural engineering, the designing and erection of large buildings, great bridges and the like, especially those of steel.—The Standard Dictionary.

Structural engineering, the construction of bridges, aqueducts, foundations, steel frames for buildings, etc.—Professor George F. Swain in Encyclopedia Americana.

Professor Swain's definition is defective in that it merely names a few types of structures and ends with an "etc." that leaves full scope to the imagination—it does not specify. The other two definitions specify "large" structures. But what is large? And why limit structural engineering to large projects? None of the three definitions excludes contractors that are not engineers.

At the outset it should be recognized that every definition of structural engineering must be somewhat arbitrary.

The structural designer is necessarily an adept in the science of strains and stresses as applied to framed works, such as buildings and truss bridges; but his vocation does not limit him to framed structures. He may be called upon to design a concrete arch bridge, or a masonry retaining wall, neither of which is "framed," in the ordinary meaning of the word. Yet in designing either a concrete arch or a retaining wall, the science of strains and stresses must be applied. Indeed, we can not think of any class of structural engineering design that does not involve extensive application of the science of strains and stresses, whereas that science plays a relatively minor part in many other branches of civil engineering. Therefore, it seems desirable to give prominence to the application of the science of elastic deformation of solids as one of the functions of the structural engineer. The word structure must be given a rather arbitrary significance if we are to exclude from structural engineering all kinds of work that fall within other classes of engineering. We must exclude earth dikes and reservoir embankments, sewers and water mains, for such "structures" are usually designed by hydraulic engineers. We must exclude engines, boilers, electric generators, electric transmission lines, and many other "structures," because they are usually designed by mechanical and electrical engineers. In fact, such a great variety of "structures" must be excluded that it becomes a hopeless task to specify in general terms that are not too general just what a structural engineering structure is.

Any attempt to define a structural engineering structure by merely enumerating the types of structures, such as buildings, bridges, etc., is not only unscientific but subject to change as new types come to be regarded as structural engineering structures.

A broad definition may be framed thus:

A *structural engineer* is an engineer who specializes in the

application of the science of strains and stresses and in the economic use of labor and materials incident thereto.

In defense of this definition it can be said that while it does not draw a sharply defined line between structural engineers and other engineers, there is, in fact, no sharp line of demarkation. Also it may be pointed out that no other class of engineers specializes in strains and stresses and the economic problems associated therewith. The hydraulic engineer, for example, should understand the principles of elastic deformation, the strengths of materials, etc., but he certainly need not be as deeply learned in these matters as is the structural engineer; and, conversely, the structural engineer need not be as skilled in the theory and economics in hydraulics as is the hydraulic engineer.

A structural engineer is primarily an engineer, or one who systematically applies science in an economic manner; but his specialty is the design and construction of those types of structures in which a knowledge of strains and stresses and the properties of materials is of paramount importance.

BY GUSTAV LINDENTHAL,

Consulting Engineer, New York City.

The report of the Committee appears to deal with methods of teaching, which concern teachers more than practicing engineers.

We know there is an undersupply of skilled structural draftsmen and an over supply of poor ones. The fault seems to be at the schools in tolerating poor drafting and handwriting. Caligraphy as such I believe is not taught at all. Most technical students are slovenly draftsmen without sufficient knowledge of descriptive geometry or of perspective or of the technique of making neat drawings. They seem to believe that kind of work beneath serious application. Yet a useful engineer must grow up from the ranks. He must be a first class, speedy and neat draftsman. Then only can he be entrusted

with detailing and designing, with computations, analysis and interpretation of specifications. Then follows the more important work in the office and shop and field. A chief engineer who has not worked himself up in that way is lacking in essential practical training and qualifications although he may have acquired thorough theoretical training. Most students are kept at school too long. The sorting out should commence with the fourteenth year. Dunces even if they be of wealthy parents should not be allowed to enter the higher classes where they act as a brake upon the progress of those mentally better qualified. Each successive year there should be a severe culling out so that only those students should be allowed to remain after their twentieth year as are worth educating for the higher branches of engineering.

All of them should be taught from the start the necessity of learning the art of self-support and earning their board unless they are so exceptionally qualified as to make it worth while for others to bear the expense of their education after they have become of age. Boys sorted out when fourteen to eighteen years old should learn trades and become mechanics, not in vocational day schools amid refined surroundings (paid for by the tax-payer), learning masonry perhaps by handling nicely varnished wooden bricks or running a lathe or other tools in elegant laboratories, but by actual fruitful work as apprentices and helpers to older and experienced mechanics in the shop, at the wall, in the quarry and mine, etc. There will be among them always some having more aptitude and ambition than others. Let these go to educational schools in the evening, there to acquire the theory of their various trades and thus become, each in his own line, a truly accomplished mechanic and worker. From their ranks we get our foremen, superintendents and practical managers. We are very short in this country of good mechanics (plumbers, masons, carpenters, stone cutters, building trades), all commanding high wages, but we are long on high school and college boys who think themselves too good for trades and are wondering why

they get only about half as much wages as a good mechanic and laborer. The fault is with our pedagogues inculcating wrong ideals.

Read the history of the early English, French and German engineers. How scant was the theoretical foundation they could obtain in their youth and how they succeeded only through hard work in making the most of their personal endowments. About 90 per cent. of present-day engineering is imitative; about 8 per cent. only is more or less progressive and only 2 per cent. original and creative.

Much of the scientific ground work for certain engineering branches can be acquired by young men before they are twenty years old. After that age their time is better employed in actual practical work. All engineers cannot become chief engineers, just as graduates of West Point cannot all become generals.

Take highway engineering. We will have to build and maintain in the United States about two million miles of highways. That will require at least 40,000 engineers of various grades year in and year out. Is it necessary that this kind of engineer should spend his time at college until he is twenty-two to twenty-four years old?

My views on engineering education are at variance with those so readily accepted by the majority. I appreciate and value the efforts made by teachers to improve and advance the art of teaching, but I am unable to fall in with some of the views advanced in the reports.

I regret that I cannot spare time to enlarge on the subject of your own report as I should like to do.

BY O. H. BASQUIN,

Professor of Applied Mechanics, Northwestern University, Evanston, Ill.

Mr. Burt's proposition that "the welfare of the commonwealth has first claim to consideration in the objects to be attained" appears to me to be satisfactory for state institutions;

for other institutions I suspect that the welfare of the student should be regarded first. If this is not the policy of the institution it seems that this attitude should be made perfectly clear to the student.

Professor Smith's paper, according to its title, relates to the training of instructors; the matter presented appears to me to relate almost exclusively to the qualifications of an instructor and how he should teach.

The first qualification presented has a distinctly Prussian flavor: "He must have a commanding bearing in relation to his classes." Again: "The teacher must be in full command in his classroom, at all sessions, whether they be lectures, recitations or design periods." This reminds one of the stories that were told of the pioneer school teacher whose first duty was to show the big boys that he could lick them, singly or in groups. I like better the third qualification given for an instructor: "He must be able to inspire and lead his students," and if one has this ability to inspire, I do not see the necessity for the forbidding mien.

One of the hobbies that I have been harping on for some time is that we ought to have a book written on "How to Teach College Men." If one wants to become informed on any science, to practice any art or trade, or even to play a game, he can generally find a book which will tell him much that he wants to know upon that particular topic. If he wants to become a college teacher, where should he go to find the instructions? So far as I know, he must read papers on particular phases of teaching, papers which do not reveal the general principles of teaching, and many of which appear to advocate conflicting views.

The principles of teaching have been formulated for teachers of secondary schools. Apparently these principles should be somewhat extended for college teaching, since our objects are somewhat different, and our pupils are certainly different. But so long as these remain the only books upon the subject, I suspect that college istructors should become familiar with

them. Teaching is applied psychology, in one of its phases, and I think a teacher will do well to become familiar with the psychology of learning and undertake to have a sound basis for the methods of teaching that he employs.

BY S. C. HOLLISTER.

The committee, in making its progress report at the 1918 meeting of the Society, divided its attack on the subject assigned to it, "Methods and Details of Teaching Structural Designs," into four parts, as follows: (1) The *objects* of structural courses; (2) the *subject matter* necessary to carry out these objects; (3) the *manner of presentation* of the subject matter; (4) the *training of instructors* to carry this out in an effective manner. Papers were then offered upon these parts, each prepared by a member of the committee.

The writer finds it difficult to present his discussion of this report without presenting, also, a statement of his viewpoint of the fundamentals of an engineering education. It would seem necessary to discuss engineering education in order to maintain a proper perspective of structural engineering curricula, both as to objects and subject matter; and to discuss engineering educational methods in general as well as the methods to be employed in the teaching of structural courses. Back of all of this lies the consideration of a change in engineering curricula in general in order to meet the new conditions which have been brought suddenly to a climax by the world war. It would seem to the writer that too little attention has been given in the report to this broader aspect of the fundamental objects of engineering education and their relation to the field of the engineer of to-day and the near future.

The object of any educational process is to awaken the spirit. It gives rise to perception, perspective, and methodical observation and thought; and arouses in the individual interest and ambition. It is dynamic and deals more with

the relationship of accumulated facts than with the retention of facts for their intrinsic value. Such a process is the foundation of a profession.

The object of an engineering education is to awaken in the individual his responsibility as an individual in political, economic and business relation with his fellows; to awaken in him consciousness of scientific fact, and the spirit of research and application of that fact; and lastly, to arouse him to convey, on broad, unbiased principles, his field of science into the practical world as a service to his fellows.

Some may say that such a conception of an engineering education is distinctly idealistic and not practical. It is as necessary to instil in the individual the spirit of a life of service through his professional activities as it is to supply him with the details of the practical phases of his work. It is this idealistic inspiration back of his daily routine duties that projects this individual with enthusiasm along a course of service. It is the living thing in his practiced profession. It is, therefore, as necessary to him as in his fund of technical information, and is as practical as living itself.

If one were to question students entering college as to their reasons for the selection of a course in engineering, the result would disclose, for the most part, superficial, immature, or even obligatory objectives. This is the result of the lack of a common conception of the field of the engineer. Again, if one were to ask the student about to graduate from an engineering course, for his idea of the engineering profession, the answer would indicate for the most part, a largely technical viewpoint of the activities of the engineer. This second answer is significant of the technically biased viewpoint resulting from the curricula in current use. Both deficiencies could be corrected by the readjustment of the activities of the engineering institutions. The second is perhaps the most vital since it is a measure of the product of the institution, and is therefore an indication of the objective of the average engineering educational system.

The engineer is entering upon a new era of usefulness in public and civic service. The problems before the nation to-day depend in a large degree upon the services of the engineer for their solution. His professional outlook has rapidly broadened, and with it has grown the necessity for application to other than the technical phases of his activity. The development has placed the engineer in a new relation with society and its very nature makes it a permanent one. An era has come when the engineer may take a position in society commensurate with the importance of the service he renders.

This change in the scope of the engineer's activities opens a field for researchful study on the part of engineering institutions as to the objectives to be attained in the near future in the engineering curricula. A study of the form of service which the engineer will be called upon to render will offer valuable suggestions as to the material to be presented in an engineering course.

It would seem that the present curriculum lacks particularly in arousing the engineer student to those phases of his practice which are not of a technical or scientific nature. He should be well grounded in the fundamentals of economic and business relations; and his course should include a fundamental study of economics, economic history, business law, corporations, banking, finance, labor problems and their history,—in short, it should set up a fundamental basis to arouse interest along the line upon which engineers of to-day and to-morrow are obliged to meet the business world. It is understood that it is not practical in any phase of this fundamental study to attempt to train the student in business details. What he should be furnished is the background upon which he may accumulate, as he progresses, the details of the work in which he is engaged.

In keeping with this larger scope of study, there are several phases of structural engineering study which might well be extended. All structural engineering is founded upon the mechanics of engineering and upon the theory of elasticity. This second subject is seldom brought to the attention of the

average engineering student as such. Yet all important structures must be considered from this viewpoint and the necessity for this consideration is rapidly broadening in extent with the growth of the modern monolithic structures. A student should be left with the most important methods of the theory of elastic structures as methods rather than as solutions for certain structures. He should have a perspective of theory that he may group structures and applications and establish proper limitations. He should be taught advanced mechanics, differential equations, if possible, and the fundamentals of advanced theories of elasticity. Text books should be used throughout which aim at such a treatment of the subject and no books should be used which just embrace the boundaries of the course.

Another distinct revision necessary in the engineering curriculum, in the opinion of the writer, is a more careful and more thorough study of English. This should be undertaken to the exclusion if need be of the study of a foreign language. The relative importance of one's own tongue and of a foreign language leaves little vindication for the partial exclusion of English from the curriculum for the purpose of obtaining an embryonic knowledge of a foreign tongue. Exclusion of the mental training involved in teaching the subject, the reason for a foreign language in the curriculum is usually explained in two ways: it may be offered to furnish the student with the basis for the development of a reading knowledge of a given language; or it may give him the basis for the development of a speaking knowledge of a given tongue. Whereas it is a decided convenience that the student gain a reading or speaking knowledge of some language other than his own, it is far better that the student take the subject as an elective, thus supplying the necessary interest to make the course a dynamic subject rather than a storehouse of latent information. The theory advanced by some that the engineering student should obtain a reading knowledge of some foreign language to make it possible for him to carry on further study in his profession

in that language is but a poor excuse for, in another sense, it may be taken as an acknowledgement of the fact that there is certain information which the student sometimes should have and that, rather than bring this information to him, it is undertaken to equip him with the basis for developing a reading knowledge of the language in the hope that some day he may run across this important work. In few other subjects in civil engineering does one find as large and important a fund of information in foreign languages which are not available in his own tongue as in the structural subjects. Though acknowledging this, it is the opinion of the writer that it is the duty of the engineering institution to collect and present this information to the student rather than equip the student with the various foreign languages so that he may seek those things out. Particularly is it emphasized that under no circumstances should the teaching of English in conjunction with structural engineering be minimized for the sake of introducing a foreign language.

It is appreciated that the courses now offered by engineering institutions have no room for this additional fundamental study. The engineering curriculum as presented in the past has offered little else than technical or scientific subjects. The engineering student has been held close to this viewpoint of the profession by such a treatment.

It must be acknowledged that there are certain distinct classes of engineers and so-called engineers; but it is believed proper, in framing an engineering curriculum, to aim directly at the higher type of engineering rather than to aim directly at the lower type of engineering appending thereto possible additional training that might develop the higher type of man. The engineering curriculum as now framed does not countenance and thereby does not encourage the broadening of a student's education by including in his course the vital subjects noted above.

It is suggested that a five- or six-year course might well be arranged, the first four years of which would lead to a prelimi-

nary degree in engineering and would be considered as a pre-engineering course. It would include many of the allied subjects suggested above as well as the elementary subjects in engineering training. At the end of the four years, the student would then have practically completed his mathematics, would have a general knowledge of surveying, of mechanical drawing and of some other elementary engineering subjects, as, for instance, a large share of engineering mechanics, statically determinate structures, railway and highway location and hydraulics. Whereas, perhaps, he would not have received an engineering education, he would, if the necessity arose, be sufficiently equipped to fill a moderately remunerative position in some mediocre branch of engineering practice.

The additional two years would continue the work of the first four years of the course and would include developmentally the most important engineering subjects of the curriculum and the most vital of the allied subjects pointed out above.

The chief essential of any educator, whether engineering or otherwise, is of necessity the ability of that instructor actually to convey to the student the objectives intended in the course. Naturally this implies that he must be well informed concerning the subject which he is teaching; but it further implies the manner in which he shall present this subject and the manner in which he shall lead his students. The treatment of the subject presented by him should be dynamic; and any instructor at any time, presenting his course toward the student as a latent thing, should be considered no longer to qualify as an educator.

The instructor should awaken in the individual the spirit of his profession and the spirit of the course as a part of that profession. If he fails to do this, he has not been successful. He must measure his efforts by the results obtained on the average student, which includes the majority of his class. If he succeeds in arousing a wholesome interest in the subject which he has presented, he need not give thought to discipline. Not

only will he be able to maintain the proper decorum in the classroom but he will be able to obtain from his students the requisite application to study. Many theories of teaching have been worked out in great detail, but these theories, practiced as such, fall down since only that teacher who is a dynamic force can bring the student into the spirit of his work, a duty when accomplished forming, in a large measure, the success of the instructor as an educator.

BY EDWARD GODFREY,

Pittsburgh, Pa.

Instruction in the details of structural design, from results that crop out in practice, in the experience and observation of the present writer, in his judgment, is in need of radical re-alignment. A number of diverse sets of facts that are the basis of the statement in the foregoing sentence will be given.

Some years ago I examined the detail drawings of two theaters which had been made by an engineering concern. The errors in details were so numerous that I did not count them. I classified them instead. There were twenty-two different kinds. Some of them were repeated many times. A number of them were so serious that they might have resulted in collapse of parts of the structure. I wrote these up for the benefit of the profession, and the article was published in *Engineering and Contracting*, December 8, 1915. Previous to this time I had written up a description of a large collection of errors in structural details from different plans that I had examined.* Some of these errors were similar in character to the others, showing the same disregard for fundamental principles of stability.

Now, it is of no particular significance that an individual, though holding himself out to be a structural engineer, should make blunders and errors. It is significant, however, that this engineer was unable to see that there was anything wrong

* *Engineering News*, April 11, 1907.

with his details, though the builder, a contractor with no engineering training except the horse sense that his experience as a contractor gave him, could see all of my points and insisted, even at much expense to himself, upon everything being made as I dictated.

The reader is referred to the published articles to see for himself whether or not the details were faulty.

But the most significant thing of all is that I was in a position where I could refer to no authority to sustain my points and to no writing except my own.

In engineering works and in the engineering class a structure seems to be a highly theoretical thing made of perfectly elastic substances that are subject to certain inexorable laws and obey those laws implicitly. But standing supreme over all of these laws is the professional judgment of the designing engineer, which ultimately sustains the loads. In my opinion the professional judgment of the designing engineer is worth practically nothing, unless he can amply sustain it by arguments that will stand the light of day and show that he has plain horse sense as well as some theoretical knowledge. In my opinion the theory of least work, and of redundant stress, and of the elastic behavior of concrete arches, and of secondary stresses due to such causes as the rotation of members on pins due to truss deflection, and most column theories, and several other nice theories, have a value only a little greater than that already ascribed to bald professional judgment.

To come right to the point, there is entirely too much theory, and there are entirely too many theories in engineering works and college teaching and not enough ordinary horse sense.

I could write a book on this subject, showing where engineers, among them some of the highest standing, have designed and discussed structures with their heads away up in the rarefied air of pure theory, while the details, that a man with scarcely any theoretical training could see were faulty,

never came into their view nor concern. A few of the high spots will be touched.

When the Quebec bridge was first erected, it was put up with a great traveler as large as a 16-story steel office building. It consisted of two side bents 217 feet high. Now horse sense tells us (though books and theory say little) that two bents of this height ought to be braced together to prevent their swaying to one side and flopping down, especially if one million pounds of weight rests on top of the bents. Did the engineers provide this bracing? No. Well, what happened? Why the two bents did tilt over, with their million-pound burden, and pulled the completed bridge over, killing about 80 men. Did the Royal Commission investigating the wreck give due warning to the profession against the recurrence of another such blunder? *In eight pounds of dope issued by the said Royal Commission there is not a word about any such possibility.* There are some nice new theories, but so far as a discussion of the real cause of the failure is concerned this report is one of the greatest farces in engineering literature.

But the Quebec bridge was rebuilt. A well-braced traveler was employed. I had publicly called attention to the blunder of the first and prophesied that in the rebuilding no such blunder would be made. Again the designing engineers had their heads in the rarefied air of pure theory and high-class problems—a la the most approved literature of engineering. Great problems were solved. The solutions do credit to the designers and to the men who handled and erected the steel. Again a detail was overlooked—a detail that it required horse sense to discover. A great load was to be lifted on a swinging support. The load was to be suspended from a long line of bars and jacked up to place. The lifting scheme was excellently worked out. But why was there a second wreck.

Makers of pails for paint suspend the pail on a bail attached as close to the top as the bail can conveniently be attached. These men know, without being able, perhaps, to tell the reason why, that if the bail is swung, say a half inch above the

middle of the height of the pail, you may be able to lift the pail without its upsetting, but the chances are that it will upset and spill the paint. Now, in raising the great suspended span of the Quebec Bridge the "bail" was hinged the trifling distance of 2¾ inches above the "center of the pail." The pail upset, after it had been lifted a few feet. Did the profession see this and publish the lesson broadcast so as to warn others. Look for yourself at current engineering publications for the few weeks following the diaster and see if you can find it. I did succeed in getting a letter published which pointed out the real cause of the wreck.*

The Orpheum Theater in New York failed completely and solely because of a monstrous curved girder of 74 feet of a span and 12 feet of an offset or versedsine, and this girder was carrying a heavy floor load. The only thing that supported this girder till its collapse was small beams that it was supposed to support. The girder flopped down and pulled with it the whole structure, just a few minutes after 200 workmen had left the building. A large and important part of engineering education is in the hands of engineering periodicals. Was the engineering profession "educated" in the accounts of this wreck? Hear the history. After about a year of investigation and delay a set of the most absurd and inane reports were published that I have ever had to read. No mention was made of the real cause of the wreck. I succeeded in getting in a statement of the cause in *Engineering and Contracting*, February 18, 1914.

What do the authorities say on the instability of curved girders? Find it, if you can. You will find some nice theories on circular girders and some applications of the same where they are totally inappropriate. Find a warning, if you can, against using a curved girder with simply supported ends. But in current engineering publications after this wreck here is what you will find—some fine spun theory on the dire effect

* *Engineering and Contracting*, October 25, 1916.

of the twisting of a girder due to deflection of a cross girder that it supports. Bosh!

Four hollow dams have failed because the pressure on the wetted side and the pressure of water beneath them was not adequately resisted by the small weight of concrete in the hollow dam. What do books on dams say of under pressure? If the word of these books is to be depended upon for information on this subject, under pressure did not exist until 1910, or, by majority vote, it does not exist at all. One book, published since 1910, emphasizes the existence of under pressure. Others do not even give it the recognition of mention. I believe that instructors have at last begun to emphasize under pressure. They ought to refuse to teach from any book that does not emphasize the necessity of designing for under pressure.

When the Stony Creek Dam, a hollow dam that failed, was rebuilt, the description of the work stated that the type of dam was in no way responsible for the failure. Yet in the rebuilding the type was changed in these important respects: it was securely anchored to a deep cut-off wall; a lot of concrete was added at the up-stream edge to give stability; a very extensive drainage system was added; and, most radical of all, the drainage system was housed in at great expense to keep it from freezing. When I, a member, attempted to discuss the matter and point out these facts in the *Proceedings of the American Society of Civil Engineers*, I was denied the privilege. This is a sample of the way engineers are being "educated."

There is enough written on the theory of the elastic arch as applied to reinforced concrete arches to fill several books. I have looked in vain for some recognition of one of the biggest single things in this design of an elastic reinforced concrete arch, namely the bending moment at the spring of the arch and provision for taking care of it. For the sake of saving a little concrete in the arch ring a highly theoretical method of design is employed, and the abutment is assumed to be ab-

solutely fixed whether its mass is sufficient to warrant this assumption or not. This method of design is based on pure theory. The elastic theory stands or falls on this premise, namely, whether or not the deflection of a reinforced concrete beam can be calculated. The deflection of a simple reinforced concrete beam cannot even be closely approximated; hence the elastic theory has no real foundation to stand on.

The use of the simple equilibrium polygon in solving a reinforced concrete arch is so simple and so appropriate to the case that it is a puzzle to me why the elastic theory should ever be brought to bear on the problem.

In reinforced concrete theories are rampant. The rodded column is based, in its use, on theory almost solely. The rodded column is a shaft of plain concrete with a rod near each corner, the rods being stayed at intervals of a foot or so by wires. Sometimes there are more than four rods. Some times they are bad enough to have rods in the middle of the side of a rectangle "stayed" with a wire in the same plane. The only thing supporting the use of a rodded column besides pure theory is a lot of misleading tests—tests of columns perfectly centered in an almost perfect testing machine. This is worse than theory because it inspires more confidence. A column, to be a proper member of a structure, must be tough. The rodded column is anything but tough, but the testing machine does not discover this.

In a score or more of bad wrecks rodded columns have proven their utter unfitness as structural members by their failure to sustain their loads and by their behavior in the wrecks. Apart from this I know of only one test of reinforced concrete columns where the thing tested resembled an actual structure and really tested a rodded column in the way it is tested as a building column. This test is described in *Engineering Record*, September 30, 1905. Here four *rodded columns* carrying two girders and a slab *failed at about 300 lbs. per sq. in.*

The theory of the rodded column does not consider the

deflection of the beams and girders connecting in a monolithic character to the columns, and the unknown eccentric stresses at the corners, and the tendency to spall on account of this eccentric stress and the shrinking of the concrete that compresses the steel and aids in this spalling. On the other hand the same class of theorists who thus ignore facts concerning concrete, a very brittle substance, will split the hair of a gnat in making up theories of secondary stresses in the heavy members of a steel structure. A steel column may have a tremendous unit stress at one corner, due to poor milling, and nothing may result except the peening of the metal. A rodded column having a corresponding condition, due to deflection of the beams, will be sure to spall and may fail and bring down the structure with it. These things are theory in one sense, but they are theory that recognizes facts and is not blind in spots. These facts are eminently common sense, and therefore it is hard to make an ingrained theoretical mind see them. Hence we have the common standards of design in reinforced concrete that are prepared and approved by two classes of men: one of these classes will accept anything that has some authoritative approval, so that it will enable them to compete with other forms of construction; the other class are laboratory investigators who cannot see any difference between an ideal laboratory experiment and a building and who make no attempt to simulate the laboratory experiment to the building.

The stirrup or short shear member in a reinforced concrete beam is another theoretical creation. Someone with a theoretical knowledge of a truss conceived the idea that stirrups or short shear members, so called, since they look like truss members on paper, can be considered as truss members. The resemblance does not extend beyond the drawing board, for truss members must have perfectly definite and full-strength connections to both top and bottom chords. Stirrups and short shear members have no such connection either to top or bottom chord or flange of a beam.

No engineer will attempt to explain how a stirrup acts to take its alleged stress nor to explain what takes the shear of a beam between two stirrups or short shear members. Engineers have ceased to discuss both rodded columns and stirrups. They are ashamed of the alleged arguments in favor of these discredited features of design. As proof of this I point to a discussion on these subjects that took place in February, 1915, when I was severely castigated in a meeting of the American Concrete Institute in Chicago. After much insistence on my part the remarks of my critics were written out (most of them) and I answered them. But the men who made the remarks were ashamed of the weakness of their arguments and had sufficient influence to prevent the publication of the discussion. I have been assured repeatedly in the last four years that the discussion would be published, though I have been convinced in my own mind from the start that these men would never let it be published.

I have a standing challenge with the engineering profession to discuss both rodded columns and stirrups and publicly declare the standards of design as regards both, and dependence upon the same, to be outrageous. But the engineer who will dare to risk his reputation by standing up publicly and alone for these absurdities has not yet arisen. In bunches and committees they will pass reports and frame codes that incorporate these false standards of design, but individuals fight shy of being held responsible for something that will not stand the light of common sense.

The reinforced concrete flat slab has given rise to some complex theories that are of no more use than discussions as to how many angels can stand on the point of a needle. The flat slab between two rows of columns is no better than a similar slab between two rows of beams and needs no more complex theories to discover its limitations, interested mathematical prestidigiteurs to the contrary notwithstanding. This simple criterion is the one that should govern both in the

making of a formula for design and in tests. But the men who have made the formulas and the tests have ignored this.

About the only practical test on a flat slab building that was a critical test was that made on the Bell St. Warehouse.* This test failed. Investigators have tested interior spots but they fight shy of a row of bays on the outside of a building where no girder exists or a row of bays across a building from outside to outside.

The flat slab and the rodded column, where tested critically, have failed to meet the requirements of the design by which they were constructed.

Now the charge I wish to make against the educators of the structural engineering profession is that by failing either to defend or condemn these wreck-breeders they are failing in their duty. Too much time is given to theoretical discussions that lead nowhere and create false impression of security, and too little time is give to common-sense discussion of the obvious causes of all wrecks, which need no higher mathematics to understand.

The engineering profession is living in a fool's paradise of fine-spun theory, and when a wreck occurs from some simple cause, they spin more fine theory to cover up the real cause of the wreck.

What ought to be done is this: cut out a lot of fine theory or let it lie embalmed in the books where it was born, and give a course in common horse-sense in the details of structural design. Let editors open their columns to a free discussion of the indefensible, the bad, the wreck-breeding features of design in reinforced concrete and steel structures and in dams.

I have written this at the request of the chairman of the Committee on Methods and Details of Teaching Structural Design. It is not written to advertise my books or writings. If there was any place else to which I could refer for material for a course such as I suggest I would gladly mention it. I

* See *Engineering News*, January 29, 1916.

have learned that the way to write books that will not sell is to say in them the things that others have not said and perhaps will not agree with. Any instructor who wishes material for a lecture course in horse sense in structural designing may be able to find these writings in some large library.

EDITORIAL.

The 1919 Meeting.—Judging from the inquiries received in regard to the 1919 meeting to be held at the Johns Hopkins University, Baltimore, Md., June 25–28, inclusive, this promises to be one of the largest meetings of the Society. Everyone is interested in the general topic of this meeting, namely, "What changes should be made in engineering education as a result of what we learned and experienced during the war." If you have any ideas on this subject, you should be present and take part in the discussion.

The Young Man and the Meeting.—The advance a young man makes in his profession is dependent to a large degree upon his acquaintance with men in that profession who are in a position to aid in his advancement. It is an important question which confronts the young man entering any profession, since promotions here must be obtained largely through personal knowledge which other men have of the young man's ability. The young engineering teacher should decide how he can best advance in his profession by increasing his acquaintance in the field of engineering education. There are two important ways to accomplish this, one through writing and publication of papers, and the other through attendance at meetings where the leaders of his profession will be found. This Society offers exceptional opportunities to the young teachers in both ways. Not only is he urged to write papers for publication in ENGINEERING EDUCATION, the bulletin of the Society, but also to be present at the annual meetings and take part in the discussion and present papers which in turn will be published in the Proceedings of the Society. It is in the publication of this Society that we look for the best that has been written or spoken in regard to engineering education. As a financial investment the young teacher can ill afford to miss attendance at these meetings.

REPORT OF AUDITING COMMITTEE.

NEW YORK, N. Y.,
February 14, 1919.

The undersigned members of the committee appointed to audit the accounts of Mr. Wm. O. Wiley, treasurer of the Society for the Promotion of Engineering Education for the fiscal year ending with the 1918 meeting, take pleasure in reporting as follows:

We have examined the vouchers, checked the entries, totals and balances and satisfied ourselves that the records are accurate and complete.

Yours respectfully,

ARTHUR H. BLANCHARD,
JAMES S. THOMPSON,
HENRY H. NORRIS,
Chairman.

THE TWENTY-SEVENTH ANNUAL MEETING OF THE SOCIETY.

The Council of the Society has voted to hold the 1919 meeting at The Johns Hopkins University, Baltimore, Md., June 25–28 inclusive. A location near Washington was decided upon at the Northwestern meeting because of the many vital questions that might be intimately connected with the men who are in government service. There are still a great many questions of policy which must be settled before the exact relation of engineering schools to the R. O. T. C. can be determined.

The Engineering School of The Johns Hopkins University is one of the more recently established schools and has many unique features which will prove of interest to visiting members. A visit to the Naval Academy at Annapolis where we are assured of a hearty welcome would prove both entertaining and instructive.

There will be a number of important questions to be discussed at the annual meeting such as the final report of the Joint Committee on Engineering Education, military training, use of psychological tests, production engineering, etc.

A Local Committee at The Johns Hopkins University has been appointed composed of the following members: J. B. Whitehead, Chairman, J. H. Bringhurst, A. G. Christie, L. A. Doggett, J. E. Greiner, M. W. Pullen, John Ridout, R. E. Root, J. B. Scarborough, Charles A. Styer, and C. J. Tilden.

NOTES.

President Hayford has appointed Dean W. E. Mott as the representative of the Society to serve as a member of the committee which the Commissioner of Education invited to confer with the specialist in commercial education in Washington, March 31, on the subject of commercial engineering.

The Secretary has received numerous requests for copies of the report of the Joint Committee on Engineering Education as prepared by Dr. C. R. Mann. Copies of this report may be secured by writing the Carnegie Foundation for the Advancement of Teaching, 576 Fifth Avenue, New York City.

There was outstanding in back dues on February 1, $6,130.84. This is practically the total income of one year. The officers of the Society are very desirous of collecting as much as possible of this amount in order that they may meet current bills. If your account is included in this amount, will you not send a check to the Treasurer, Mr. W. O. Wiley, 432 Fourth Avenue, New York City, in order that the Society may not only meet the current bills but also that it may do the work which it should during the period of reconstruction.

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27th Annual Meeting

At

The Johns Hopkins University

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June 25th to 28th, 1919

The Bulletin of the Society for the Promotion of Engineering Education

PUBLICATION COMMITTEE

John F. Hayford, Milo S. Ketchum, F. L. Bishop

The Bulletin is the official organ of the Society. It is published monthly from September to June. It contains not only the text of papers presented before the Society, but also college notes, short contributions from members, and matters of general interest to all persons connected directly or indirectly with technical education.

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